Palestine Polytechnic University

College of Engineering

Building Engineering

Graduation Project

Structural Design of Transylvania Hotel in Hebron city

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This project submitted to the College of Engineering in partial fulfillment of requirements of the Bachelor degree of Civil Engineering

Hebron – Palestine

DEDICATION

To Mom and Dad, family and friends.

To our competitors and supporters.

To caffeine and sugar, our companions through long nights.

To everyone that has made us the persons who we are.

Also, we dedicate this simple work for our teachers who tries to simplify the engineer science for us

Acknowledgement

Thanks be to Allah for this guidance and providence!

we would like to take the opportunity to whole heartedly thank to everyone who supported us

we especially thank:

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All lecturers at the university.

we would especially like to thank Eng. Inas Shweky, who extended Great effort on the project.

Everyone who helped in the project and got great help.

Stractural Design Of Transylvania Hotel in Hebron city

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Razan Hamdan **Ruba AL - Jabaree** **Yousef Amro**

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Abstract:

The structural design is considered as one of the most important stages in the building , The concept of structural design in Civil Engineering can be summarized as the practice of all activities related to the mathematical modeling and analysis of civil structures , such as supporting foundations ,residential buildings ,bridges .

The aim of this project is the structural analysis and design for the constituent elements of the project for (Transylvania Hotel) which is located in Hebron city and consist of 10 floors (2 basement , ground , services , first ,5 duplicate floors) with a total site area of 29938 m2 . In this stage all columns locations should be determined in a way that goes with the architectural design in order to make the plans executable, and determining the loads for the building based on the Jordanian code.

The structural design of the elements will be done based on the American code (ACI) , and determine live loads according to Jordanian code, after that each structural element will be analyzed and designed using some of engineering programs such as ATIR, SAFE, ETABS. In the end, the executive plans will be prepared for all the structural elements of the building structure to make the building feasible

التصميم الانشائي لفندق ترانسلفانيا في مدينة الخليل

اعداد :

ربى الجعبري **رزان حمدان** **يوسف عمرو**

اشراف :

م . ايناس شويكي

الملخص:

يعتبر التصميم الإنشائي من أهم مراحل البناء ، ويمكن تلخيص مفهوم التصميم الإنشائي في الهندسة المدنية على أنه ممارسة جميع الأنشطة المتعلقة بالنمذجة الرياضية وتحليل الهياكل المدنية ،مثل الأساسات الداعمة والمباني السكنية والجسور.

الهدف من هذا المشروع هو التحليل والتصميم الإنشائي للعناصر المكونة لمشروع (فندق ترانسلفانيا) الذي يقع في مدينة الخليل ويتكون من 10 طوابق (2 تسوية ، 1ارضي ، 1خدمات ،1 اول ، 5 طوابق) مع تبلغ مساحة الموقع الإجمالية 29938 م 2 ، في هذه المرحلة يجب تحديد جميع مواقع الأعمدة بطريقة تتماشى مع التصميم المعماري من أجل جعل الخطط قابلة للتنفيذ وتحديد الأحمال للمبنى بناءً على الكود الأردني.

سيتم التصميم الإنشائي للعناصر بناءً على الكود الأمريكي (ACI) ، وتحديد أحمال الزلزال وفقًا لرمز UBC-97 ، وبعد ذلك سيتم تحليل وتصميم كل عنصر هيكلي باستخدام بعض البرامج الهندسية مثل ATIR, SAFE, ETABS, في النهاية تم إعداد المخططات التنفيذية لجميع العناصر الهيكلية لهيكل المبنى لجعل البناء مجدياً.

List of Abbreviations:

- **A_c** = Area of concrete section resisting shear transfer.
- **A_s** = Area of non-prestressed tension reinforcement.
- **$A_s^\backslash$ =** Area of non-prestressed compression reinforcement.
- **A_g** = Gross area of section.
- **A_v** = Area of shear reinforcement within a distance (S).
- **At** = Area of one leg of a closed stirrup resisting tension within a (S).
- **a** = The distance of the compression zone from the top of the section
- **b** = Width of compression face of member.
- **b_w** = Web width, or diameter of circular section.
- **c** = The distance of the neutral axis from the top of the section.
- **C_c =** Compression resultant of concrete section.
- **C_s** = Compression resultant of compression steel.
- **D.L** = Dead loads.
- **d** = Distance from extreme compression fiber to centroid of tension reinforcement.
- **E_c** = Modulus of elasticity of concrete.
- **f_c** = Compression strength of concrete.
- **f_y** = Specified yield strength of non-prestressed reinforcement.
- **h** = Overall thickness of member.
- **L_n** = Length of clear span in long direction of two- way construction, measured face-to-face of supports in slabs without beams and face to face of beam or other supports in other cases.
- **L.L** = Live loads.
- **L_w** = Length of wall.
- **M** = Bending moment.
- **M_u** = Factored moment at section.

- **M_n** = Nominal moment.
- **P_n** = Nominal axial load.
- **P_u** = Factored axial load
- **R_n** = A strength coefficient of resistance.
- **S** = Spacing of shear or in direction parallel to longitudinal reinforcement.
- **V_c** = Nominal shear strength provided by concrete.
- **V_n** = Nominal shear stress.
- **V_s** = Nominal shear strength provided by shear reinforcement.
- **V_u** = Factored shear force at section.
- **W_c** = Weight of concrete. (Kg/m^3).
- **W** = Width of beam or rib.
- **W_u** = Factored load per unit area.
- X_{III} = the distance of region **III**.
- **Φ** = Strength reduction factor.
- **ε_c =** Compression strain of concrete = 0.003mm/mm.
- **ε_s =** Strain of tension steel**.**
- **$\acute{\varepsilon}_s$=** Strain of compression steel.
- **ρ** = Ratio of steel area.

CONTACTS

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CHAPTER ONE: INTRODUCTION.

1.1 INTRODUCTION:

The growth of hotels among history is associated with the growth of cities, and because of the increase In the tourism rate in Palestine hotels were established, and these establishments are still popular all around the world.

Hotels are more important than ever because of the important role that they play in attracting tourists From around the world, it is also considered an important factor in increasing the economy of country. hotels may be considered as an indicator of the development of a city.

1.2 PROJECT PROBLEM:

In order to come up with an integrated hotel design, the designer must collect data, and literature Review and analyze case studies.

The level of success that a hotel reaches depends on the degree of customer satisfaction, so it is successful.

The hotel should avoid problems that may reduce its level of performance. For example, as we have noticed in previous projects, there is not enough space available for all activities that require customers, in addition to the limited space of the rooms.

In our project, we will address these problems in line with careful structural analysis and design, and study the balance of the building to avoid, no danger to the dwellings, in this project all structural elements such as beams and panels will be designed, Columns and columns, all dead and live loads for each element will be calculated according to the code.

All the structural elements will be analyzed in line with the scientific qualifications and skills that we gained through studying in the field of engineering professions. We are also able to improve our skills in structural design.

why this project was chosen?

There are many reasons that led to the selection of this project, including the reasons as follows:

1. The project is a Hotel that enables us to cover the most things we studied and there is a difference in elements in hospitals (slabs, beams, columns …etc.) that lead to make a experience in design, analyze and detailing, in line with the scientific qualifications and skills that we gained through studying in the field of engineering.
2. Because this project is needed in our society and the need to implement buildings in an engineering manner.
3. The need to increase the experience and skill of structural design, which we studied .

1.3 PROJECT OBJECTIVES:

- Improving the style and performance of hotels in the country and creating an unexpectedly high quality.
- Identifying the suitable solution for any problem in the design.
- Create an integrated design that goes with all standards and codes.
- Integration between design requirements and standards.

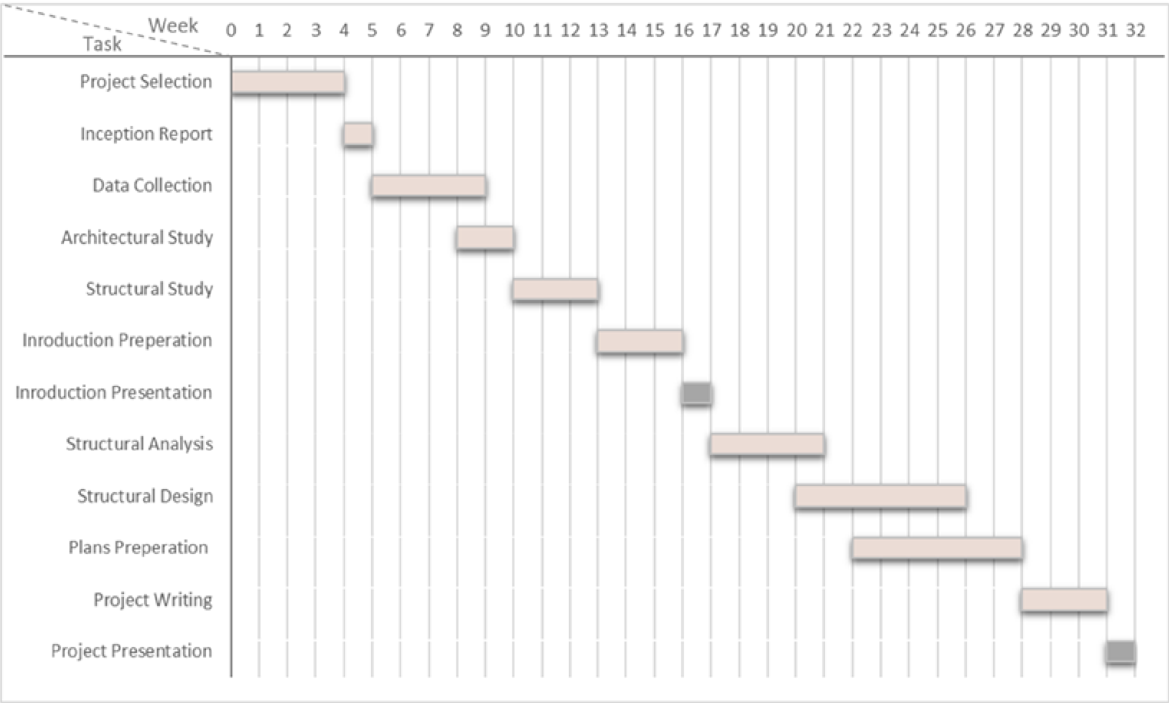
1.4 METHODOLOGY:

To achieve the objectives of the project following steps were followed:

1. Architectural study in which the site, building plans, and elevations were been studied.
2. Structural planning of the building, in which the location of columns, beams, and shear walls was determined to fit with architectural design.
3. Structural study in which all structural members were identified and different loads were been estimated.
4. Design and analyze structural elements according to the ACI Code.
5. Preparation of Structural drawings of all existing elements in the building.

1.5 PROJECT TIME TABLE:

The following chart shows timeline for the project through the first semester 2022-2023 and the expected timeline for the second semester 2022-2023:



1.6 PROGRAMS WE WILL BE USE:

1. Microsoft Office for text writing and editing.
2. AUTOCAD 2020: for detailed drawings of structural elements.
3. ATIR18: Structural design and analysis of structural elements.
4. Safe16: design of slabs & footings .
5. SpCoulmn: for design the columns.
6. Found: for design foundation.
7. Etabs17: design of shear wall elements.

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CHAPTER TWO: ARCHITECTURAL DESCRIPTION

2.1 INTRODUCTION

Architectural description is the most important things that should be consider when preparing for any project because of its importance in defining and understanding the nature of the project and its sections.

Architectural design requirements task must meet the desired job and human needs in the present time, these terms are in the functional, lasting beauty and economy, it is important in these conditions can interact between each other and in harmony to achieve our vision of optimal design and get an integrated and comprehensive architectural design, and this is achieved by understanding the functional demands of the building and space as well as taking into account nature movement of each part of the project.

Architectural study that must precede the start of architectural design must be easy to handle and understand different events that it contains building and functional relations among them, and the nature of the association movement and using these parts, and other things of importance that give a clear picture of the project and therefore it will be possible to locate the columns , shear walls and other structural elements to suit architectural design.

2.2 GENERAL IDENTIFICATION OF THE PROJECT

The land area is 18114 square meters and it is located in Hebron in the Nemra area. The area for all floors, it is about 30000 square meters, and it contains two basement floors, one ground floor, and floors above the ground, a service floor, a first floor, and five duplicate floors.

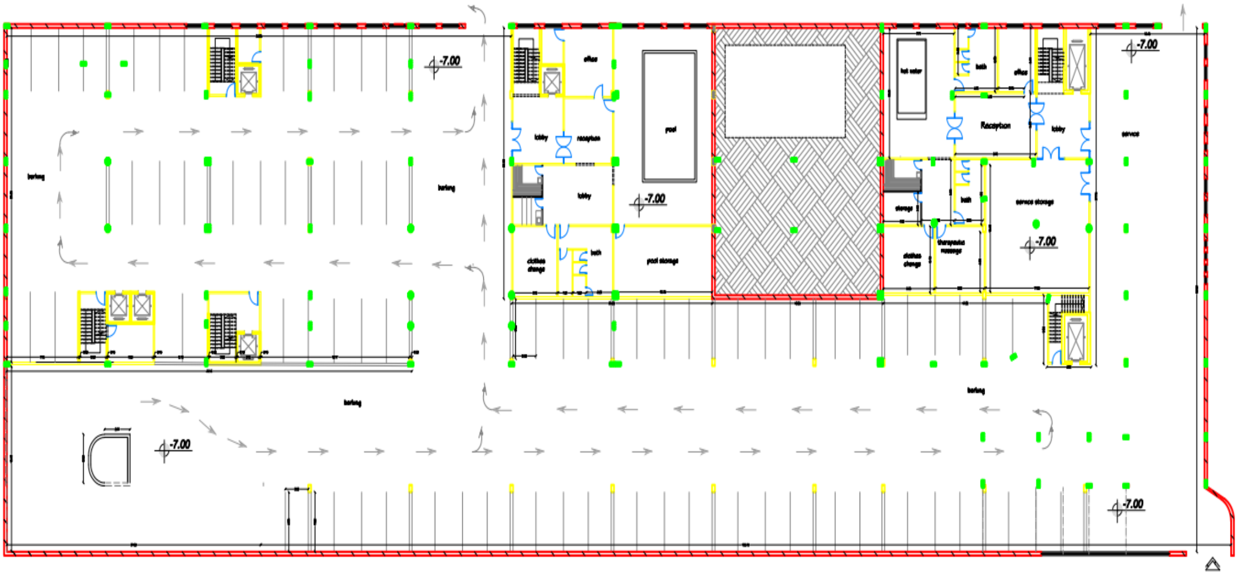
.Figuer (2. 1) : Site Plan Of Project.

2.3 FLOORS DESCRIPTION

Project contain two basement floors, ground floor, service floor, first floor, and five duplicate floors , the area of all floors is 29938m^2 and these sections describe the floors plans, elevations and sections

2.3.1 SECONED BASEMENT FLOOR

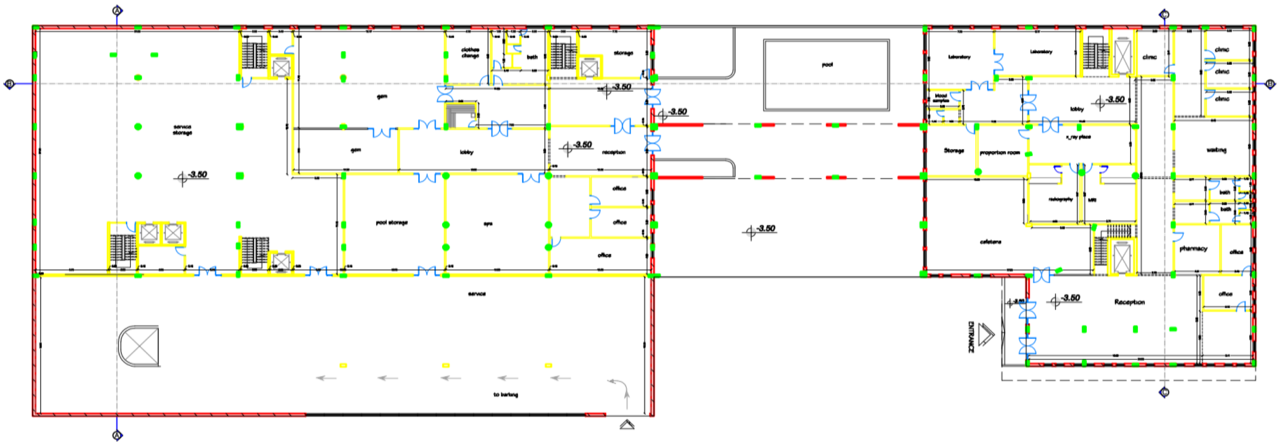
The area of this floor 5728 m^2 it contain 88 parking for cars and pool , the level of this floor is (-7m)



Figuer (2 .2) : second basement floor plan.

2.3.2 FIRST BASEMENT FLOOR

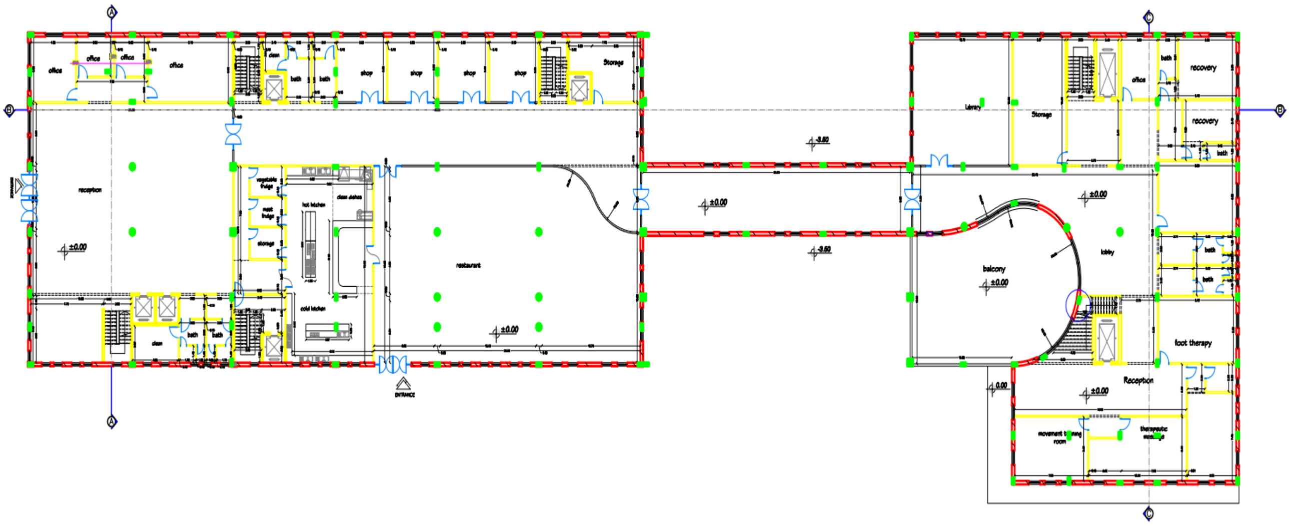
The area of this floor 4968 square meters contains stores, gym, centers, laboratories and clinics, the level of this floor is (-3.5 m).



Figuer (2 .3) : first basement floor plan.

2.3.3 GROUND FLOOR

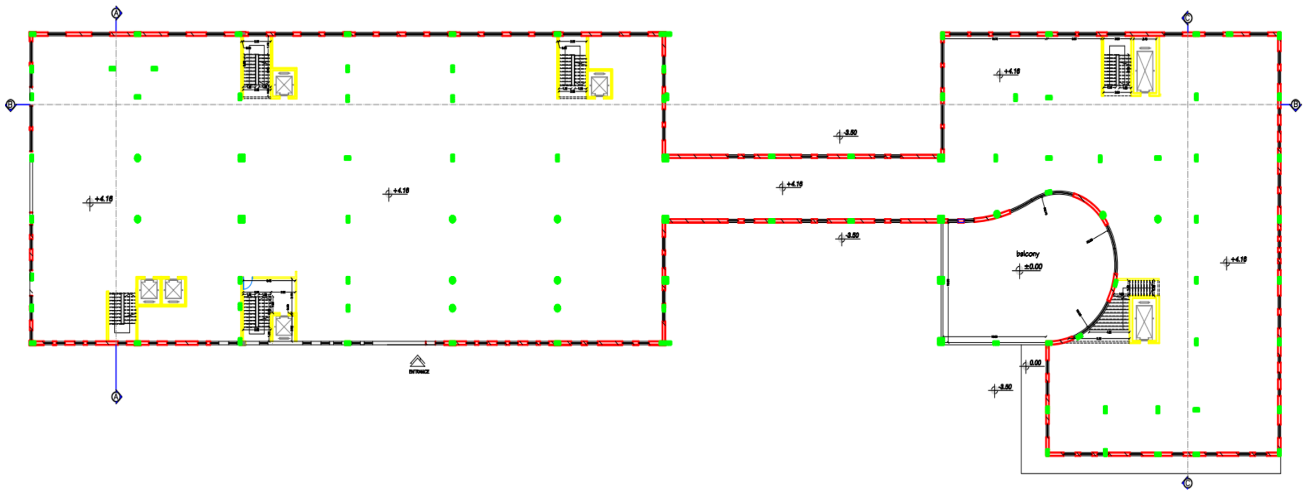
The area of this floor is 3295 square meters and contains restaurants, offices, shops, a skin care center and stores, the level of this floor is (+-0.00m).



Figuer (2 .4): ground floor plan .

2.3.4 SERVICE FLOOR

The area of this floor is 3295 square meters ,the level of this floor is (+4.16)



Figuer (2 .5): service floor plan.

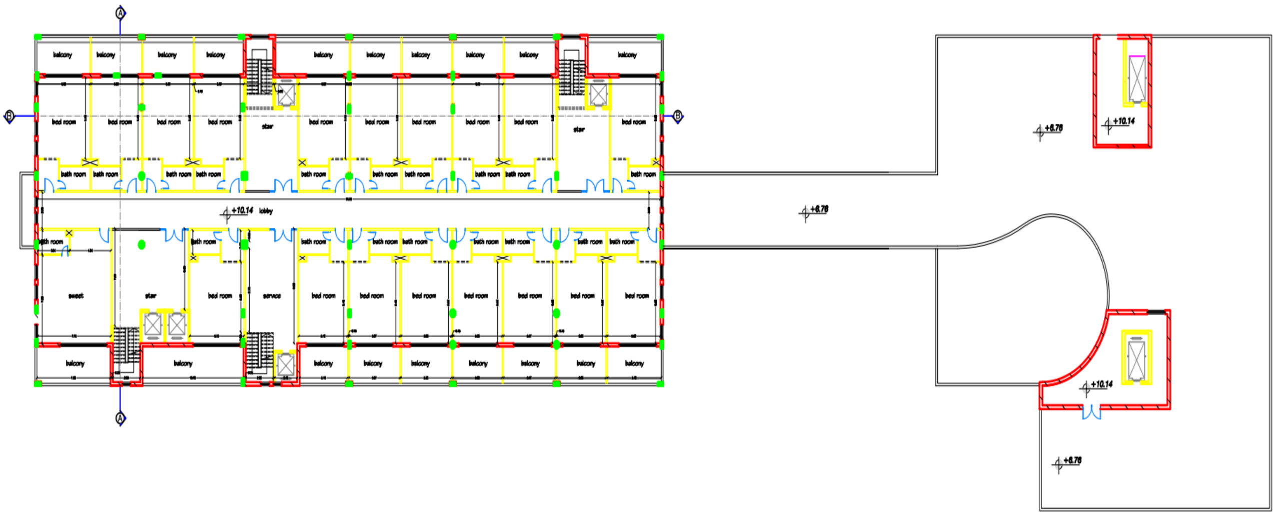
2.3.5 FIRST FLOOR

The area of this floor is 3295 square meters, containing hotel bedrooms, the level of this floor is (+6.76m).

Figuer (2 .6): firs floor plan.

2.3.6 (2^{nd} , THIRD, FOURTH, FIFTH AND SIXTH) FLOOR

This five duplicate floors have an area of one floor of 1871.4 square meters, and each floor contains 19 hotel bedrooms, the level of this floor is (+10.14m).



Figuer (2 .7): second floor plan.

2.4 ELEVATIONS DESCRIPTION

2.4.1 NORTHERN ELEVATION

This elevation shows the northern side of the building, which shows the entire building with all its floors, including basment 1, besment 2, and the inclination of the land.

The right side of the building shows the bedroom floors, while the left side shows treatment centers and restaurants.

Figuer (2 .8): northern elevation.

2.4.2 SOUTHERN ELEVATION

This elevation shows the southern side of the building, which shows part of the basement floor 1 and part of the basement floor 2 due to the inclination of the site's land, in addition to the rest of the entire floors.

The right side of the building shows the treatment centers, restaurants and their entrance, while the left

Figuer (2 .9): southern elevation.

2.4.3 EASTERN ELEVATION

This elevation shows the eastern side of the building with the treatment centers and restaurants in the foreground and the bedroom floors in the back.

Figuer (2 .10): eastern elevation

2.4.4 WESTERN ELEVATION

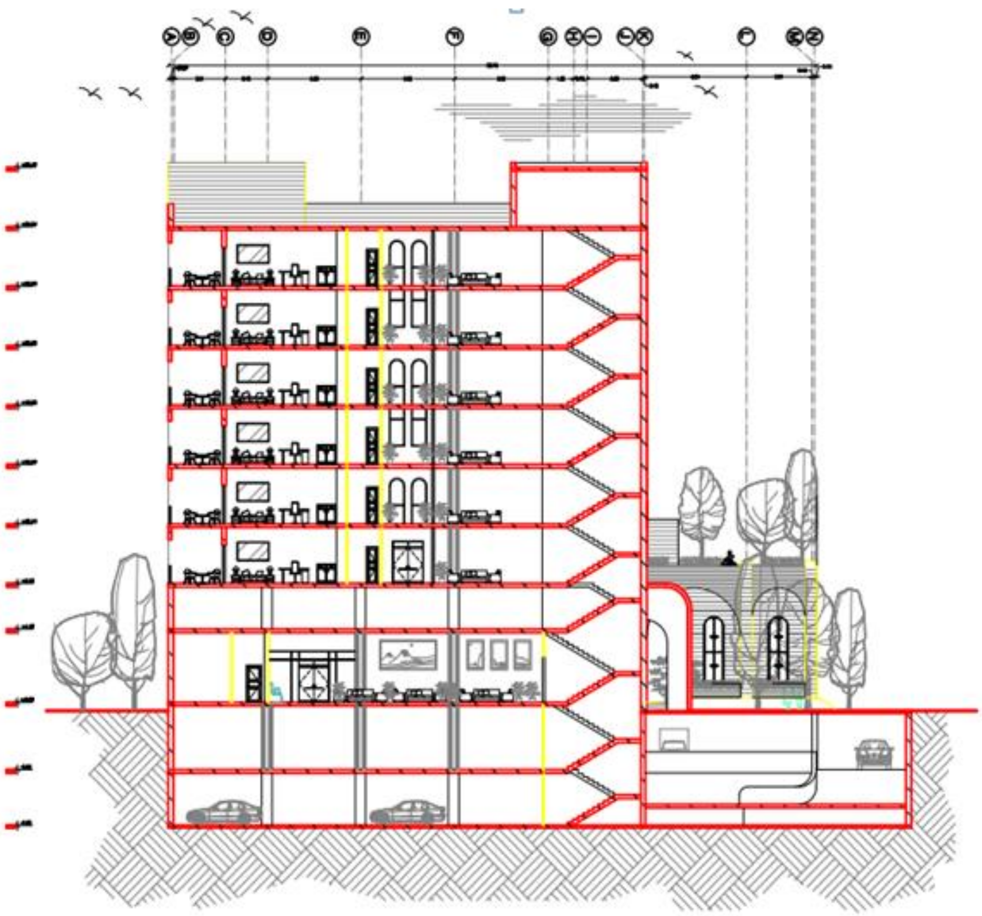
This elevation shows the western side of the building and shows the main entrance to the building so that in the foreground is the entrance to the reception and above it (bedroom floors) and it shows part of the building of the treatment and dining centers.

Figuer (2 .11): western elevation.

2.5 SECTIONS OF THE BUILDING

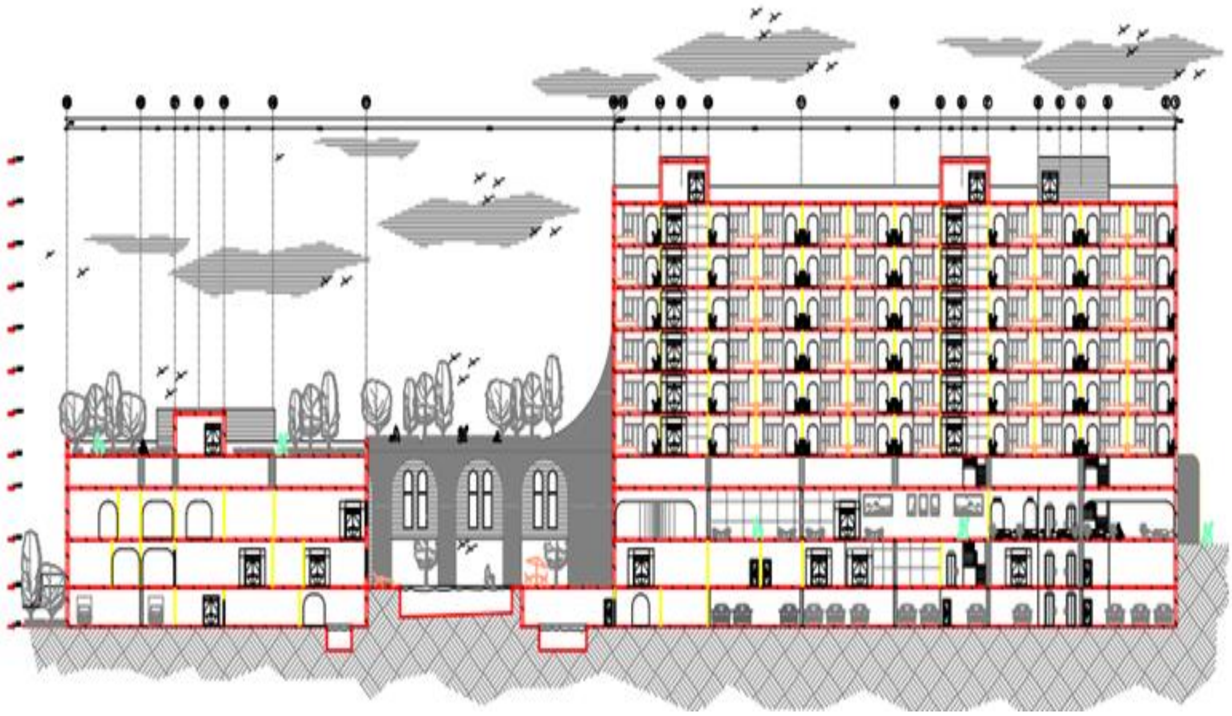
The vertical movement in the building is through staircases, elevators, and ramps, while the horizontal movement is through corridors.

In this section(section A-A), the right side shows the pedestrian entrance and the car entrance



Figuer (2 .12): section A-A.

In this section (section B-B) , the right side shows the entrance and exit for pedestrians.



Figuer (2 .13): section B-B.

In this section(section C-C) the northern side shows the pedestrian entrance

Figuer (2 .14): section C-C.

3

CHAPTER THREE: STRUCTURAL DESCRIPTION

3.1 INTRODUCTION

The main objective of the process design is to ensure the existence of necessary operating advantages with structural elements on the most suitable dimensions in terms of security andeconomic terms.

The knowledge of structural elements of any project is essential in the design of reinforced concrete structures to make comparisons between different types of these elements for the construction of safer system. So the structural elements that go into the design of this project will be described.

3.2 THE AIM OF THE STRUCTURAL DESIGN

The structural design is an integrated and balanced structural system capable of carrying it meet the established requirements and desires of users, and thus determines the structural elements from the following:

1. Factor of Safety: Is achieved by selecting sections for structural elements capable of with standing the forces and resulting stresses.
2. Economy: Check by choosing the appropriate building materials and by choosing the perfect low-cost section.
3. Serviceability: To avoid excessive landing (deflection), fissures (cracks).
4. Preservation of architectural design.
5. Preserving the environment.

3.3 SCIENTIFIC TESTS

Before the design of any construction project must be doing some tests, tests of the soil to see breaking strength, specifications, type, the underground water level and depth of the foundation layer, and through holes up and depths measured.

3.4 STAGES FOR STRUCTURAL DESIGN:

We will distribute the structural design of the project in two phases: -

1. The first stage: - In this stage, the appropriate structural system of project construction and analysis for this system will be determined.
2. The second stage: - The structural design of each element of the set is detailed and accurate according to the chosen construction system .

3.5 LOADS ACTING ON THE BUILDING:

Is a group of forces that are designed to endure, and that any building is subjected to several types of loads must be calculated and selected carefully because any error in identifying and calculating loads reflects negatively on the structural design of various structural elements. The building is exposed to loads of live and dead loads, wind loads, snow loads, loads of earthquakes.

The permanent forces and resulting from strong gravity which are fixed in terms of amount and location and does not change during the age of the building, and the loads on the weight of structural elements and the weights of the items based upon sustainably as cutters and walls, as well as the weight of the body adjacent to the building permanently, and the calculation and estimate the loads by knowing the dimensions of the structural elements and specific gravity of the material used in the manufacture of structural elements, And are most often include: concrete, and Rebar, and plaster, and bricks, tiles and finishes, and the stone used in building coverage abroad, there is also a tube extension, as well as suspended ceilings and decorations for the building.

3.5.1 DEAD LOADS

Table (3. 1) Determination of Dead load

Material	Quality Density (kN/m^3)
Tiles	23
Mortar	22
Sand	17
Topping	25
RC Rib	25
Block	24
Plaster	22

3.5.2 LIVE LOADS

Which are the loads that are subjected to buildings and constructions depending on varioususes, including distributed and concentrated loads, which include the following:

1. The weights of the Hotel users.
2. Dynamic loads, such as cars.
3. Static loads, which can be changed from time to time, such as furniture, machines, static unstable machines, stored materials, equipments.

table (3. 2) Determination of live load

Live loads for hotel from Jordanian code	4 KN/M^2

3.6 STRUCTURAL ELEMENTS OF THE BUILDING

All buildings are usually consisting of a set of structural elements that work together to maintain the continuity of a building and its suitability for human use, and the most importantof these slabs and beams and columns and load-bearing walls, etc.

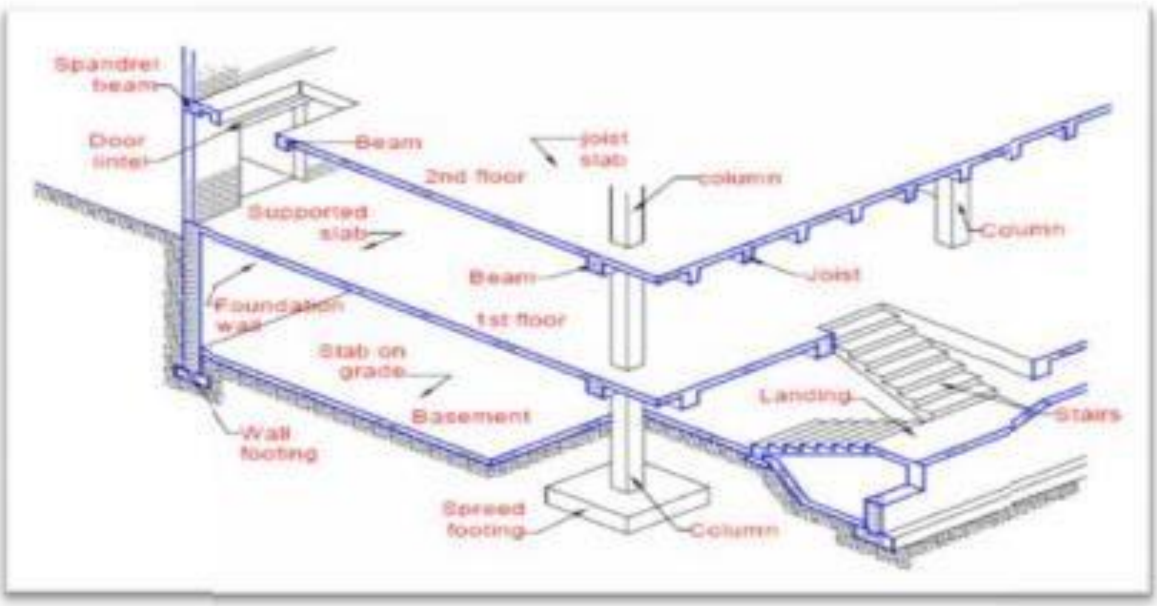


Figure (3 .1) Structural Elements of the building

3.6.1 SLABS

Structural elements are capable of delivering vertical forces due to the loads affecting the building's load-bearing structural elements such as beams, columns, and walls, In this project, two types of components both in its appropriate place, and which will clarify the structural design in the subsequent chapter, and below two types:

One -Way Ribbed Slab and Solid Slab

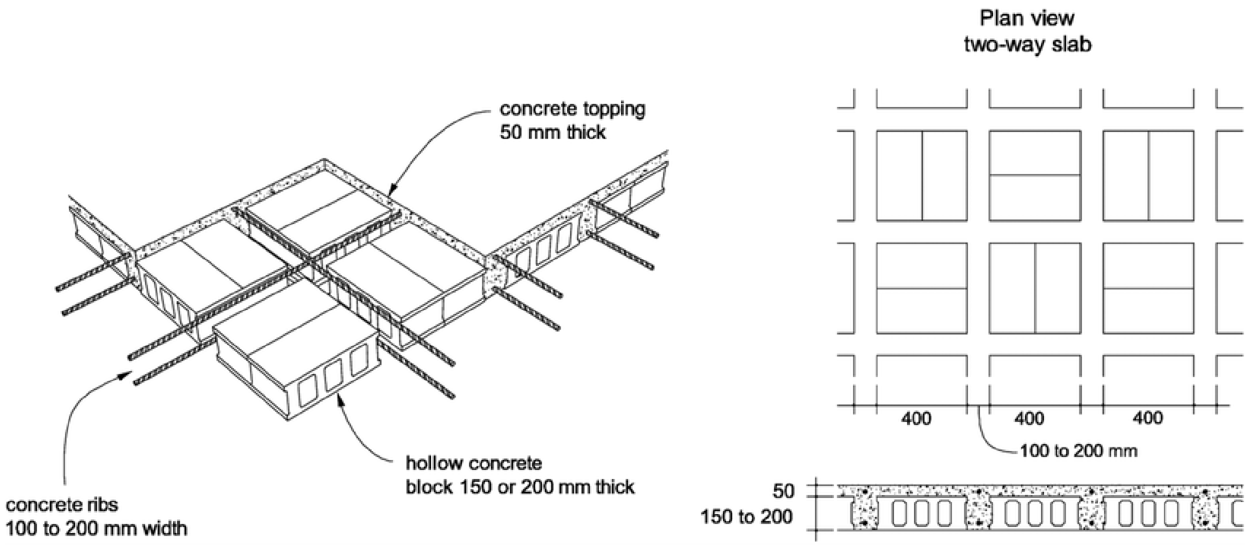


Figure (3 .3) Two Way Ribbed Slab.

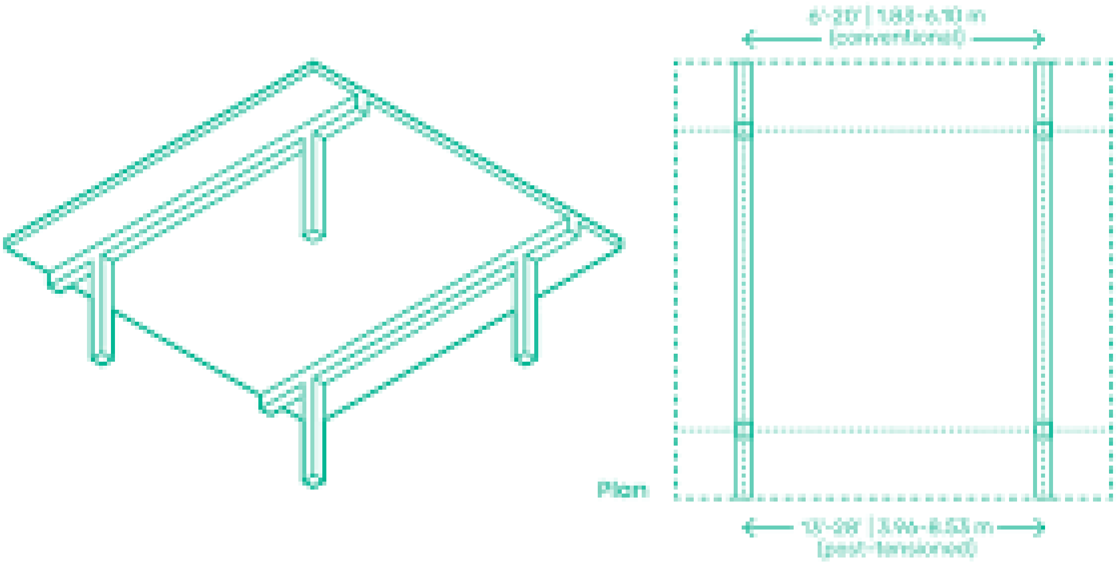


Figure (3 .2) One -Way and Solid Slab

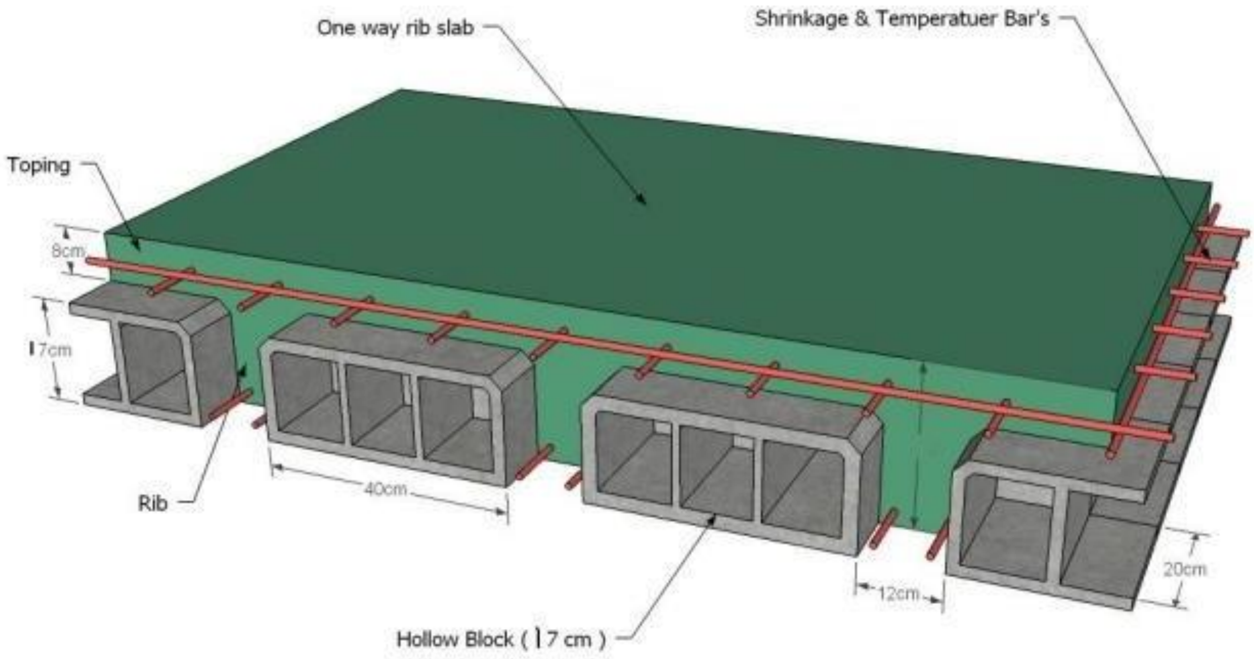


Figure (3 .4) One Way Ribbed Slab

3.6.2 STAIRS

The architectural elements used for vertical transmission between the different levels of through the building .

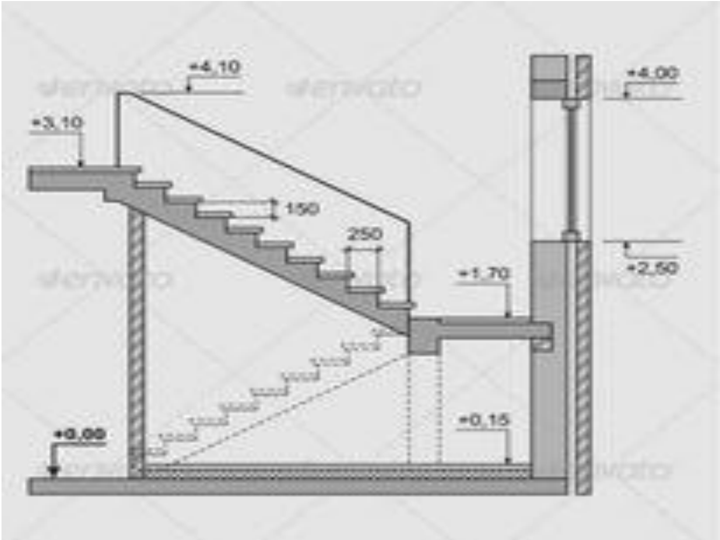
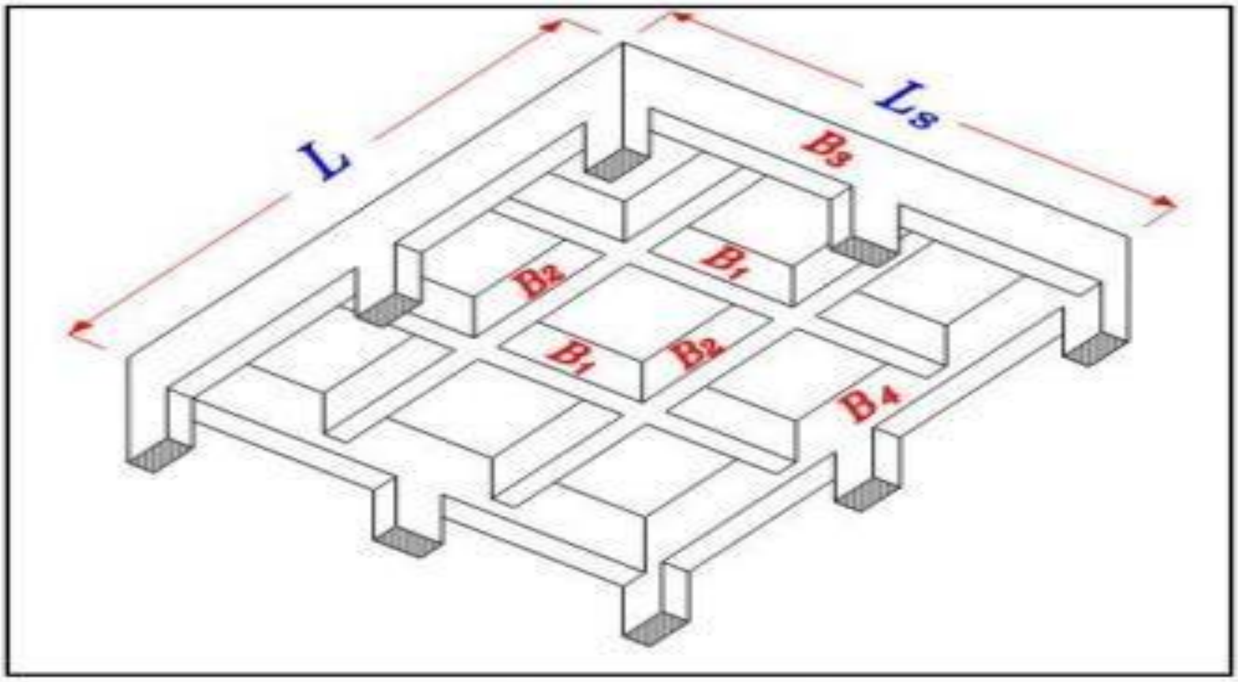


Figure (3 .5) Shape of stairs

3.6.3 BEAMS

The basic structural elements in moving load of tiles into columns, and are of two types:

1. Hidden Beam



2. Dropped Beam: (Drop Beam) like (T-section , L-section , or rectangular beams).

Figure (3 .6) Drop Beam

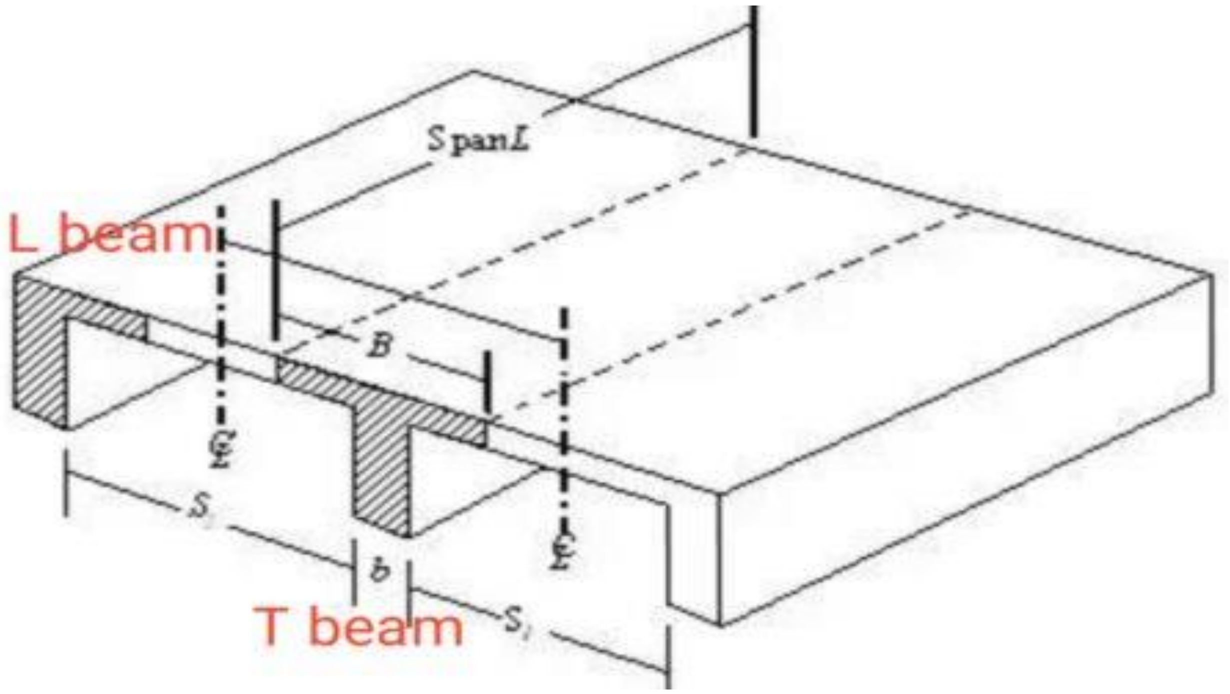


Figure (3 .7) T-Section and L-Section

3.6.4 COLUMN

The column is an important element in moving loads of beams to the foundations, it is essential to transfer the loads of the building, and therefore must be designed so as to beable to resist the load.

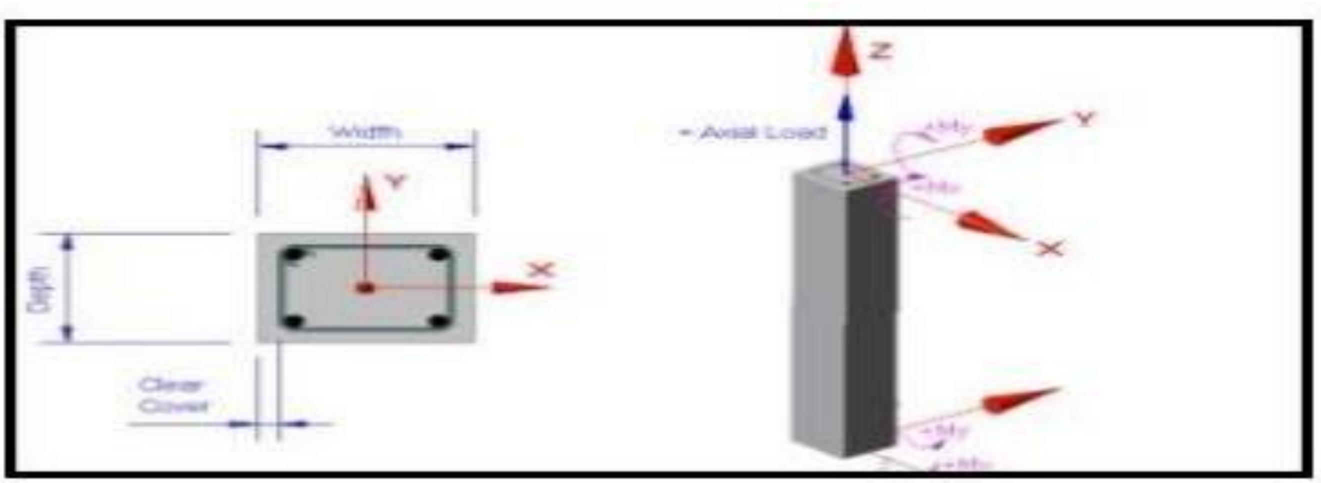


Figure (3 .8) Column

3.6.5 SHEAR WALL

What is a Shear Wall?

Shear wall is a structural member in a reinforced concrete framed structure to resist lateral forces such as wind forces. Shear walls are generally used in high-rise buildings subject to lateral wind and seismic forces. In reinforced concrete framed structures the effects of wind forces increase in significance as the structure increases in height. Codes of practice impose limits on horizontal movement or sway.

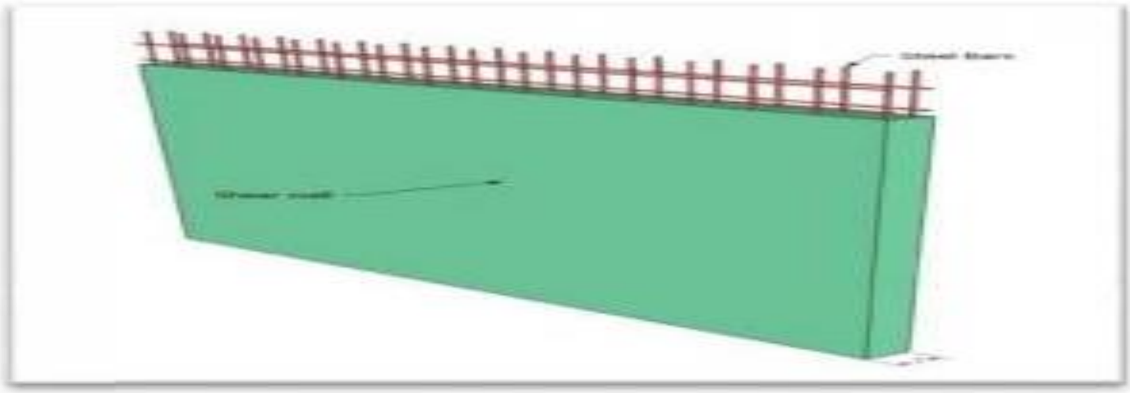


Figure (3 .9) Shear Wall

3.6.6 FOUNDATION

Although the foundations are the first element constructs, but we did the design after the completion design all the structural elements in the building. The foundations are the link between the structural elements in the building and the earth. The loads on the slab move to the beams and then to the columns and finally to the foundations to the soil. The foundation is responsible for carrying the dead loads of the building and also the dynamic loads resulting from earthquakes. Also Live loads inside the building. We determined the type of foundations depending on the strength of the soil and the loads on each footing.

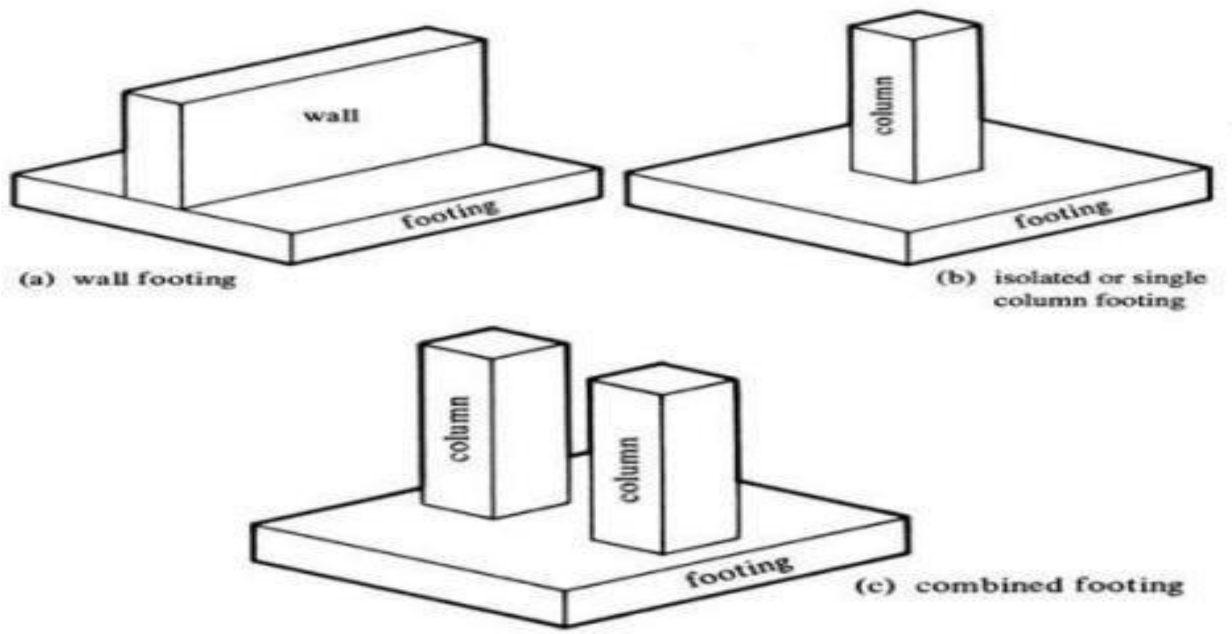


Figure (3 .10) Foundations

4

CHAPTER FOUR: STRUCTURAL ANALYSIS AND DESIGN

4.1 Introduction

4.2 Factored Loads

4.3 Determination of Thickness

4.1 INTRODUCTION:

Concrete is a construction material composed of cement (commonly Portland cement) as well as other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate such as gravel, limestone, or granite, plus a fine aggregate such as sand), water, and chemical admixtures. The word concrete comes from the Latin word "concretus", which means "hardened" or "hard."

Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material. Concrete is used to make pavements, architectural structures, foundations, motorways/roads, bridges/overpasses, parking structures, brick/block walls and footings for gates.

In This Project, there are two types of slabs: one-way solid slabs and one-way ribbed slabs. They would be analyzed and designed by using finite element method of design, with aid of a computer Program called " ATIR- Software" to find the internal forces, deflections and moments for ribbed slabs, and then hand calculation would be made to find the required steel for some members.

The design strength provided by a member, its connections to other members, and its cross-sections in terms of flexure, and load, shear, and torsion is taken as the nominal strength calculated in accordance with the requirements and assumptions of ACI-code

4.2 FACTORED LOADS.

The factored loads on which the structural analysis and design is based for our project members, is determined as follows:

$q_u = 1.2DL + 1.6L$ ACI – 318 - 08(9.2.1)

4.3 DETERMINATION OF THICKNESS:

Determination of Thickness for One Way Rib Slab:

The structure may be exposed to different loads such as dead and live loads. The value of the load depends on the structure type and the intended use.

The overall depth must satisfy ACI Table (9.5.a):

Spans from left to right for one-way slab:

Figure (4. 1)Check of Minimum Thickness of Structural Member

Member	Simply supported	One end Continuous	Both end continuous	Cantilever
solid one way slabs	L/20	L/24	L/28	L/10
Beams or ribbed one way slabs	L/16	L/18.5	L/21	L/8

The minimum required thickness for hotel is:

The maximum span length for one end continuous (for ribs) is 5.59m.

$h_{min} = \frac{l}{18.5} = \frac{5.59}{18.5} = \mathbf{30.2cm}$ >> **CONTROL**

The maximum span length for both end continuous (for ribs) is 6.11m.

$h_{min} = \frac{l}{21} = \frac{6.11}{21} = 29.09$ cm

we select h= 32cm (24cm block + 8cm topping).

4.4 LOAD CALCULATION:

One - way ribbed slab.

For the one-way ribbed slabs, the total dead load to be used in the analysis and design is calculated as follows:

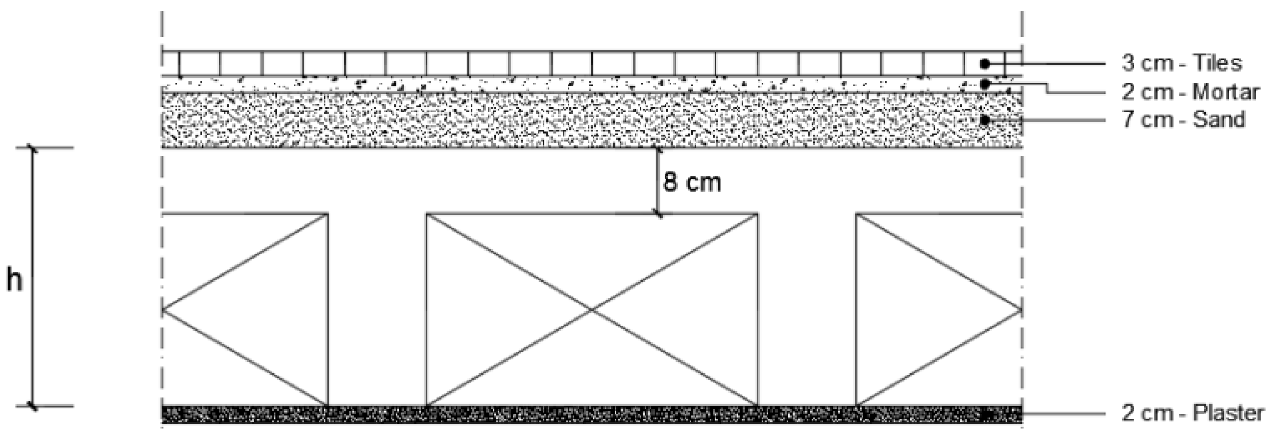


Figure (4. 2) One-way rib slab

Calculation of the total dead load for one-way rib slab is shown in the following table:

Table (4. 1) Calculation of the total dead load for one-way rib slab.

Material	Quality Density (kN/m^3)	Calculation	Dead Load (kN/m)
Tiles	23	= 0.03*23*0.52	0.358
Mortar	22	= 0.02*22*0.52	0.228
Sand	17	= 0.07*17*0.52	0.618
Topping	25	= 0.08*25*0.52	1.04
RC Rib	25	=0.24*25*0.12	0.72
Block	20	=0.24*20*0.4	1.92
Plaster	22	=0.03*22*0.52	0.343
Partitions		=2.5*0.52	1.3
∴ Dead Load for rib =5.7Kn/m / Rib			

Live lood = 4*0.52= 2.08KN/m/Rib

4.5 DESIGN OF TOPPIN:

Design of Topping for Ribbed Slab:

When designing the topp part of slab (topping) take a strip with a width of one meter to calculate the load on topping. Where the two ends of this strip are considered fixed to resist moment (Fixed Support).

Table (4. 2) Calculation of the total dead load for topping.

1	**Tile**	**0.03*23*1= 0.69 KN/m**
2	**mortar**	**0.0**2***22*1=** 0.44**KN/m**
3	**Coarse sand**	**0.07*17*1= 1.19 KN/m**
4	**topping**	**0.08*25*1 = 2.0 KN/m**
5	**Interior partitions**	**2.** 5***1 =2.** 5**KN/m**
Sum		6.82 **KN/m**

W_u = 1.2 DL + 1.6 LL

= 1.2 * 6.82 + 1.6 * 4= 14.58KN/m^2. (Total Factored Load)

$M_u = \frac{W_u * l^2}{12} = \frac{14.58 \times 0.4^2}{12}$ = **0. 19445kN.m**

- Vu = $\frac{W_u \times L}{2} = \frac{14.58 \times 0.4}{2}$ = **3.35 kN**
- Mu = $\frac{W_u \times L^2}{12} = \frac{14.58 \times 0.4^2}{12}$ = **0. 19445kN.m**

Ø $M_n \geq M_u$, **where** Ø=0.55 (for plain concrete)

Mn=0.42 $\boldsymbol{\lambda\sqrt{fc'}}$ ***S_m***

Where S_m for rectangular section of the slab:

$S_m = \frac{b\,h^2}{6} = \frac{1000 \times 80^2}{6}$ =1066666.67mm^3

$M_n = 0.42\ \lambda\sqrt{fc'}\ S_m = 0.42 \times 1 \times \sqrt{24} \times 1066666.67 \times 10^{-6}$ = 2.19 kN.m

Ø M_n = 0.55 × 2.19 = 1.207 KN.m >> M_u= 0.19445kN.m

N0 reinforcement is required by analysis.According to ACI 10.5.4, provid As,min for slabs as shrinkage and temperature reinforcement.

According to ACI 7.12.2.1, $\rho \text{ shrinkage} = 0.0018$

$A_s = \rho bh = 0.0018 \times 1000 \times 80 = 144 \text{ mm}^2$ for 1m strip

Try bars Ø8 with A_s = 50.27mm^{2}.

Bar numbers n=$\left(\frac{As}{As,Ø8}\right)$= $\left(\frac{144}{50.27}\right)$=2.87.

Take 3Ø8/m with A_s = 150.8mm^2/m strip or Ø8@ 300mm in both directions.

Choosing (S) is the smallest of:

1. 3h = 3 × 80 = **240 mm** >>> Controlled **ACI (10.5.4)**
2. 450mm.
3. S = $380\left(\frac{280}{f_s}\right) - 2.5C_c = 380 \left(\frac{280}{\frac{2}{3}420}\right) - 2.5 .20 = 330\text{mm}$ **ACI (10.6.4)**
4. S $\leq 300 \left(\frac{\mathbf{280}}{\mathbf{f_s}}\right)$ = 300 mm

So, Take Ø 8 @ 200 mm in both direction, S = 200 mm <S_{max} = 240 mm … OK

4.6 DESIGN OF RIB 14

Material: -

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section: -

b =12cm b_f=52 cm

h =32cm T_f=8 cm

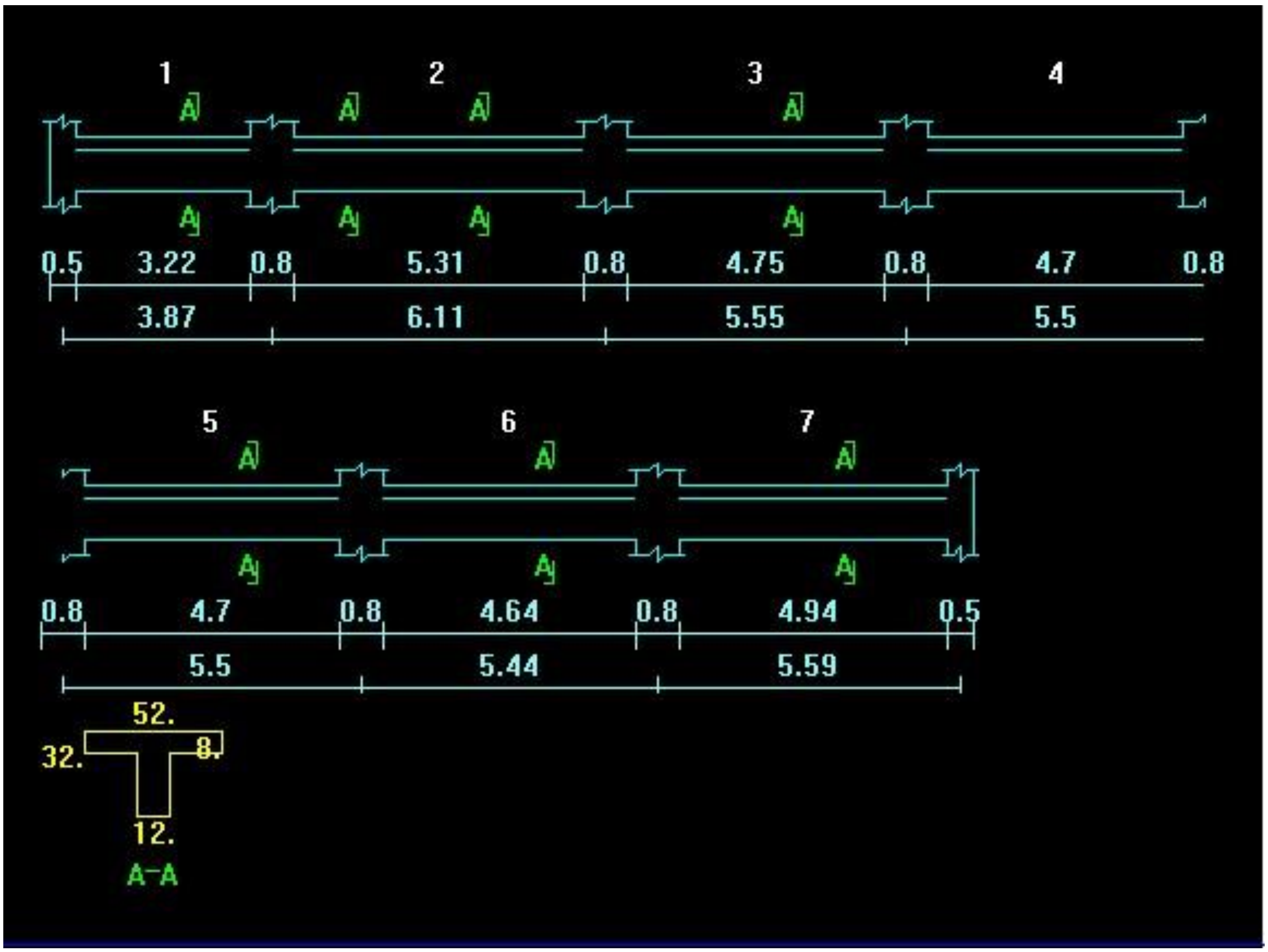


Figure (4. 3) rib geometry

Reactions

Factored

DeadR	10.49	47.29	50.42	45.27	47.07	44.02	52.76	18.63
LiveR	6.2	20.21	22.12	21.37	21.78	21.03	22.29	8.29
MaxR	16.69	67.5	72.54	66.65	68.85	65.05	75.05	26.93
MinR	8.44	53.32	58.43	52.22	54.8	50.64	61.04	17.71
Service								
DeadR	8.74	39.41	42.01	37.73	39.23	36.68	43.97	15.53
LiveR	3.88	12.63	13.83	13.36	13.61	13.14	13.93	5.18
MaxR	12.62	52.04	55.84	51.09	52.84	49.83	57.9	20.71
MinR	7.46	43.18	47.02	42.07	44.06	40.82	49.14	14.95

Figure (4. 4) loading of rib

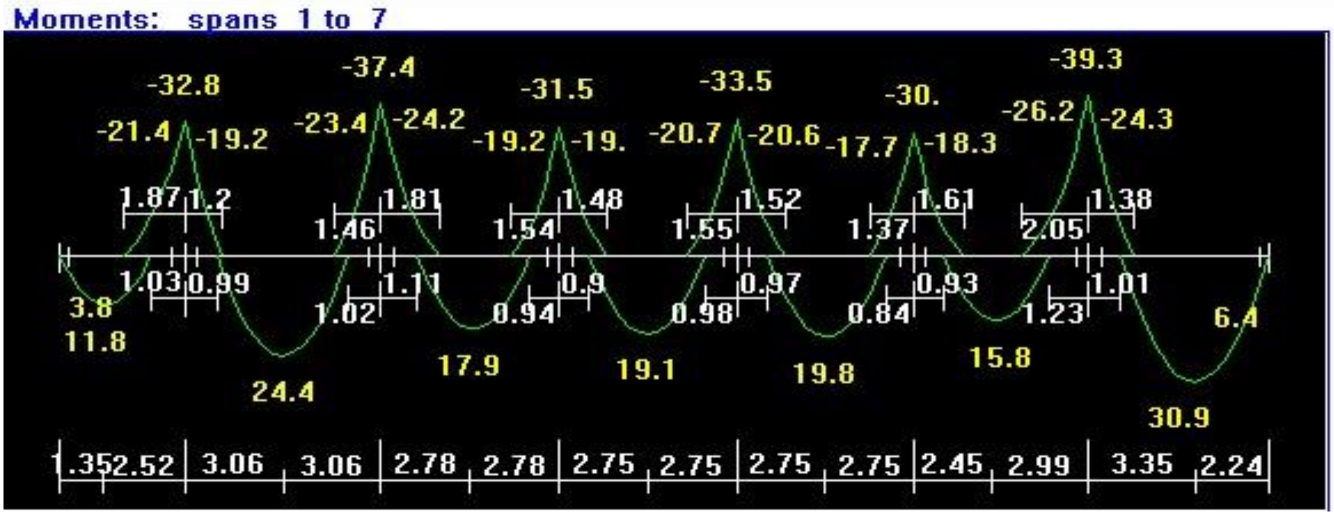


Figure (4. 5): Moment Envelop of rib (14)

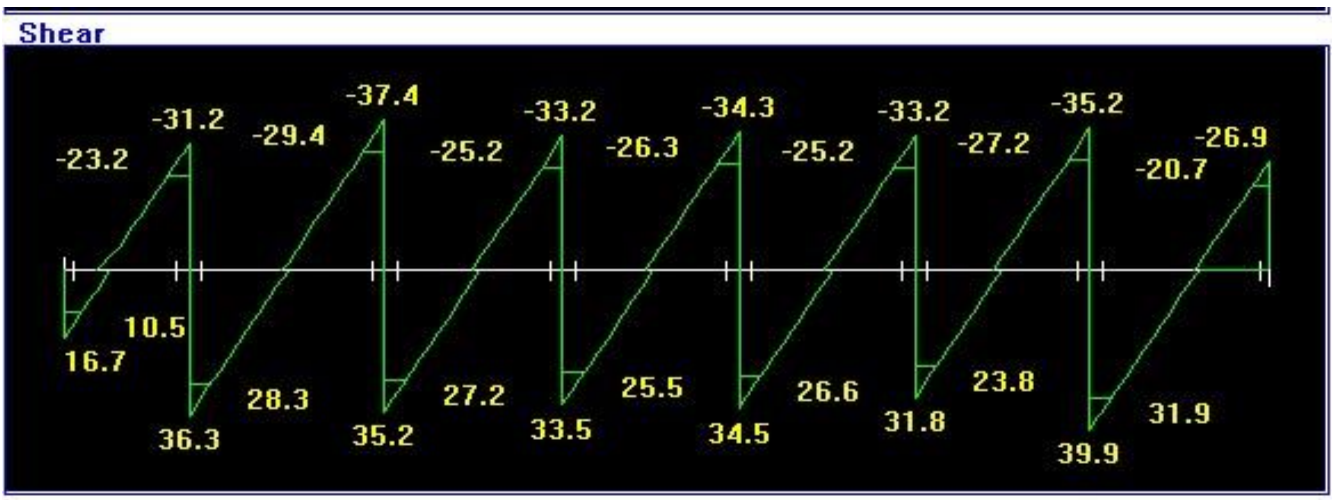


Figure (4. 6): Shear Envelop of rib (14)

Design of Positive Moment for (Rib 14) :- (Mu max =30.9 Nm.)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $s_{tirrups} - \frac{d_b}{2} = 320 - 20 - 10 - \frac{12}{2} = 284\ mm$

Check if a>h_f to determine whether the section will act as rectangular or T- section.

$M_N = 0.85.f_c'.b_e.h_f.(d - \frac{h_f}{2})$

$= 0.85 \times 24 \times 520 \times 80 \times \left(284 - \frac{80}{2}\right) \times 10^{-6} = 207.06$ KN.m

M_N = 207.06 $\gg \frac{M_u}{\varphi} = \frac{30.9}{0.9}$= 34.33 Nm. , the section will be designed as rectangular section with b_e =520 mm.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{30.9\times10^6}{0.9\times520\times284^2} = 0.8186\ Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.588$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.588}\left(1 - \sqrt{1 - \frac{2\times20.588\times0.8186}{420}}\right) = 0.001989$

A = ρ.b.d = 0.001989 ×520×284 = 293.7 mm^2

Check for As min:-

$As\ min = \frac{\sqrt{fc'}}{4(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$As\ min = \frac{\sqrt{24}}{4(420)}(120)(284) = 99.37 mm^2$

$As\ min = \frac{1.4}{(fy)}(bw)(d)$

$As\ min = \frac{1.4}{420}(120)(284) = 113.6 mm^2$ **control**

As_{req}= 293.7 mm^2 < As_{min}= 113.6 mm^2

Use 2∅14 with $As_{provided}$ = 307.9 mm2 > As_{min}= 113.6 mm^2 ….Ok

Check for strain:-

$a = \frac{A_s.f_y}{0.85 b\ f_c'} = \frac{307.9\times420}{0.85\times520\times24} = 12.19\ mm$

$\beta = 0.85$

$c = \frac{a}{\mathcal{B}_1} = \frac{12.19}{0.85} = 14.34\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{284\ -14.34}{14.34}\right) = 0.056 > 0.005 \qquad \mathbf{0k}$$

Design of Negative Moment for (Rib14):- (Mu max=-26.2 KN.m)

Assume bar diameter ø 12 for main positive reinforcement

d =h- cover - $d_{stirrups} - \frac{d_b}{2} = 320 - 20 - 10 - \frac{12}{2} = 284\ mm$

Check if $a > h_f$ to determine whether the section will act as rectangular or T- section.

$M_{nf} = 0.85. f_c'. b_e. h_f. (d - \frac{h_f}{2})$

$= 0.85 \times 24 \times 120 \times 80 \times \left(284 - \frac{80}{2}\right) \times 10^{-6} = 47.78\ \text{KN. m}$

$M_{nf} = 47.78 \gg \frac{M_u}{\varphi} = \frac{26.2}{0.9} = 29.1$ KN.m , the section will be designed as rectangular section with b_e =520 mm.

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{26.2\times10^6}{0.9\times120\times284^2} = 3.007\ Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.588$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.588}\left(1 - \sqrt{1 - \frac{2\times20.588\times3.007}{420}}\right) = 0.007783$

$A_{s,req} = \rho.b.d = 0.007783\times120\times284 = 265.24\ mm^2$

Check for As min:-

$As\ \min = 0.25\frac{\sqrt{fc'}}{(fy)}(bw)(d)$ **ACI-318 (10.5.1)**

$As\ \min = 0.25\frac{\sqrt{24}}{(420)}(120)(284) = 99.37 mm^2$

$As\ \min = \frac{1.4}{(fy)}(bw)(d)$

$As\ \min = \frac{1.4}{420}(120)(284) = 113.6 mm^2$ **control**

$As_{req} = 265.24\ mm^2 > As_{min} = 113.6\ mm^2$ **OK**

Use 2∅14 with $As_{provided}$ = 307.9 mm^2 > As_{req}=265.24 mm^2 ….Ok

Check for strain:-

a $=\frac{A_{s}.f_y}{0.85\ b\ f_c'} = \frac{307.9\times420}{0.85\times120\times24} = 52.8mm$

c$= \frac{a}{\mathcal{B}_1} = \frac{52.8}{0.85} = 62.117\ mm$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{284-62.117}{62.117}\right) = 0.0107 > 0.005 \qquad \mathbf{0}\boldsymbol{k}$$

Moment Design for (R 14) :-

positive Moment for (Rib 14) span1 (5.59):- (Mu=30.9 Nm.)

Asreq= 281.58 mm2

Use 2Ø14 with Asprovided = 307.9 mm2

Negative Moment for (Rib14):- (Mu=-24.3 KN.m)

Asreq= 244.319 mm2

Use 2Ø14 with Asprovided = 307.9 mm2

positive Moment for (Rib 14) span2(5.44):- (Mu=15.8 Nm.)

As_{req}= 148.56 mm^2

Use 2Ø10 with $As_{provided}$ = 157.1 mm^2

Negative Moment for (Rib14):- (Mu=-26.2 KN.m)

As_{req}= 263.34 mm^2

Use 2Ø14 with $As_{provided}$ = 307.9 mm^2

positive Moment for (Rib 14) span2(5.5):- (Mu=19.1 Nm.)

As_{req}= 180.18 mm^2

Use 2Ø12 with $As_{provided}$ = 226.2 mm^2

Negative Moment for (Rib14):- (Mu=-20.7 KN.m)

As_{req}= 188.608 mm^2

Use 2Ø12 with $As_{provided}$ = 226.2 mm^2

positive Moment for (Rib 14) span2(5.5):- (Mu=19.8 Nm.)

As_{req}= 186. 8 mm^2

Use 2Ø12 with $As_{provided}$ = 226.2 mm^2

Negative Moment for (Rib14):- (Mu=-20.6 KN.m)

As_{req}= 204.44 mm^2

Use 2Ø14 with $As_{provided}$ = 307.9 mm^2

positive Moment for (Rib 14) span2(5.55):- (Mu=17.9 Nm.)

As_{req}= 168.63 mm^2

Use 2Ø12 with $As_{provided}$ = 226.2 mm^2

Negative Moment for (Rib14):- (Mu=-24.2 KN.m)

As_{req}= 243.29 mm^2

Use 2Ø14 with $As_{provided}$ = 307.9 mm^2

positive Moment for (Rib 14) span2(3.87):- (Mu=11.8 Nm.)

As_{req}= 110.77 mm^2

Use 2Ø10 with $As_{provided}$ = 157.1 mm^2

Negative Moment for (Rib14):- (Mu=-21.4 KN.m)

As_{req}= 213.05 mm^2

Use 2∅12 with $As_{provided}$ = 226.2 mm^2

positive Moment for (Rib 14) span2(6.11):- (Mu=24.4 Nm.)

As_{req}= 231.001 mm^2

Use 2∅14 with $As_{provided}$ = 307.9 mm^2

Negative Moment for (Rib14):- (Mu=-23.4 KN.m)

As_{req}= 234.538 mm^2

Use 2∅14 with $As_{provided}$ = 307.9 mm^2

Design of shear of rib (RIB 14):

1) Vu = 31.9 KN.

$V_c = \frac{\sqrt{f'_c}}{6} * b_w * d$

$= 1.1 * \frac{\sqrt{24}}{6} * 0.12 * 0.284 * 10^3 = 30.61$ KN.

$\phi V_c = 0.75 * 30.61 = 22.95$ KN.

→Check for Cases: -

1- Case 1: $V_u \leq \frac{\phi V_c}{2}$.

$31.9 \leq \frac{22.95}{2} = 11.47$

∴ Case (1) is NOT satisfied

2- Case 2: $\frac{\phi V_c}{2} < V_u \leq \phi V_c$

$11.47 \leq 31.9 \leq 22.95$

∴ Case (2) is NOT satisfied → shear reinforcement is required.

$Vs = \frac{V_u}{\phi} - Vc = 11.92$

$Vs\ max = \frac{2}{3} * \sqrt{f'_c} * d * b_w = \frac{2}{3} * \sqrt{24} * 284 * 120 * 10^{-3} = 111.3$

$Vs' = \frac{Vs\ max}{2}$ 55.65 =

Vs min= $\frac{1}{16} * \sqrt{f_c'}$ * b_w* d =10.43

Vs min= $\frac{1}{3}$* b_w* d = 11.36 ....Control.

<u>Try 2Φ8: -</u>

$\frac{100.5*420*284}{S}$ = $11.36*10^3$ → S = 1055.25mm.

S ≤ $\frac{d}{2}$ = $\frac{284}{2}$ = 142mm. … Control

≤ 600 mm.

∴ Use 2Φ8 @ 1 3.5Cm

4.7 DESIGN OF BEAM (31)

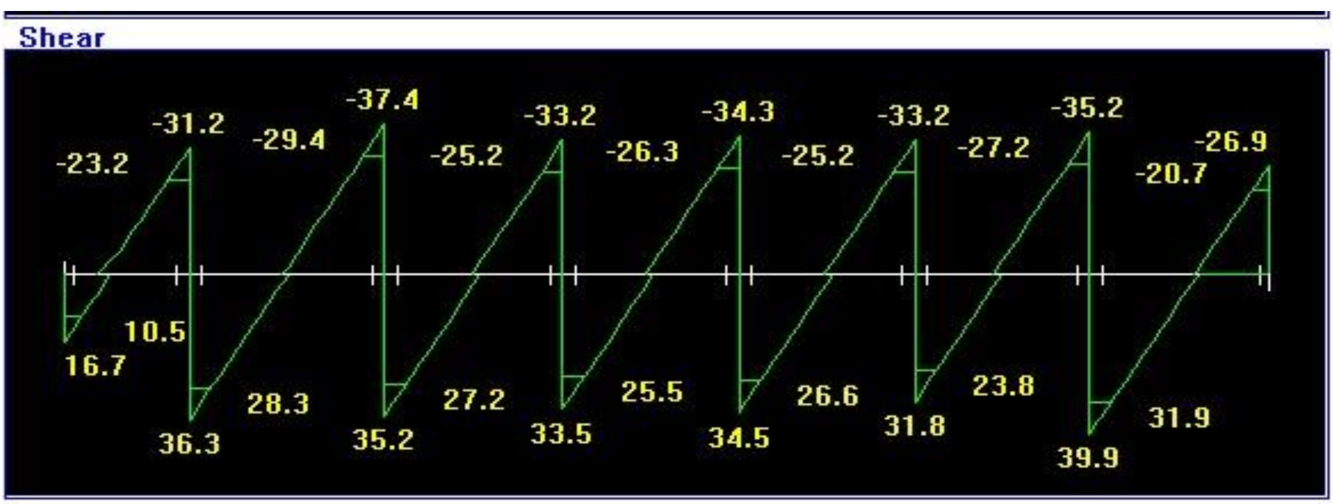


Figure (4 .7) Beam Geometry.

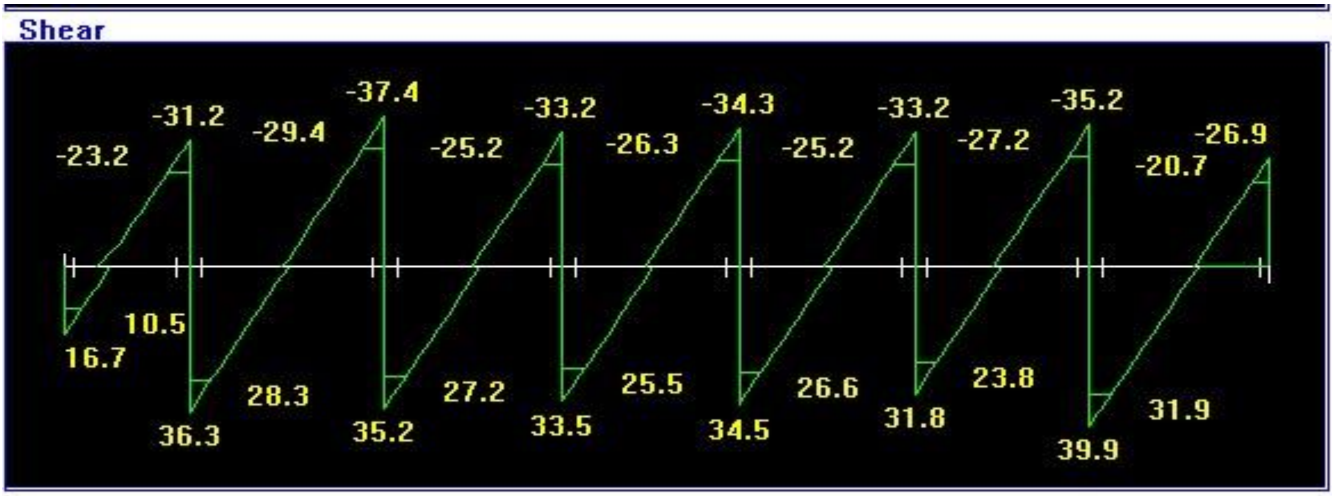


Figure (4 .8) Load of Beam

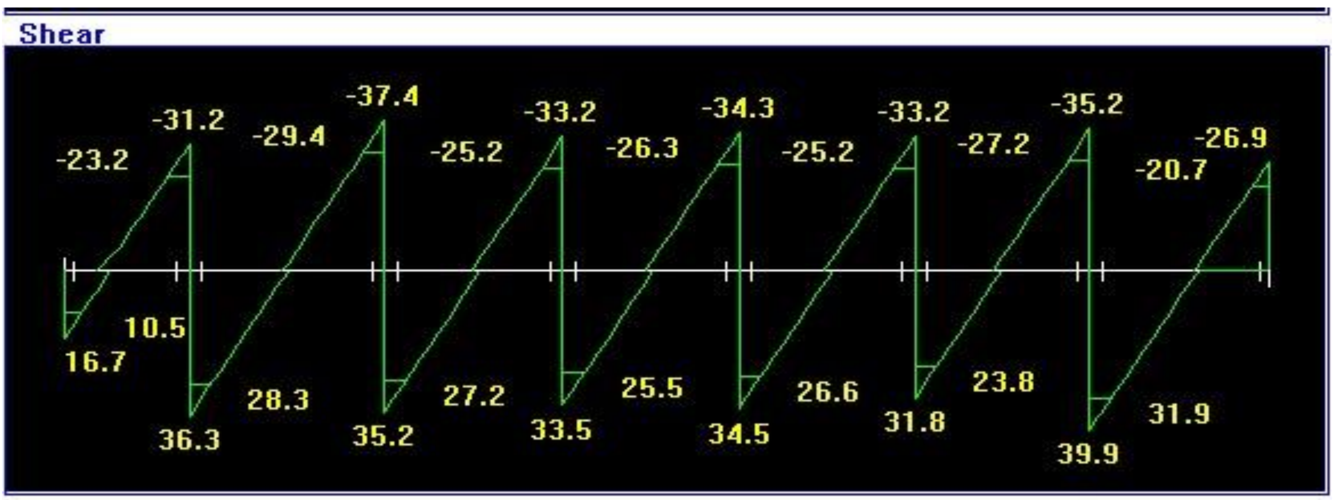


Figure (4 .9) Moment Envelop for Beam

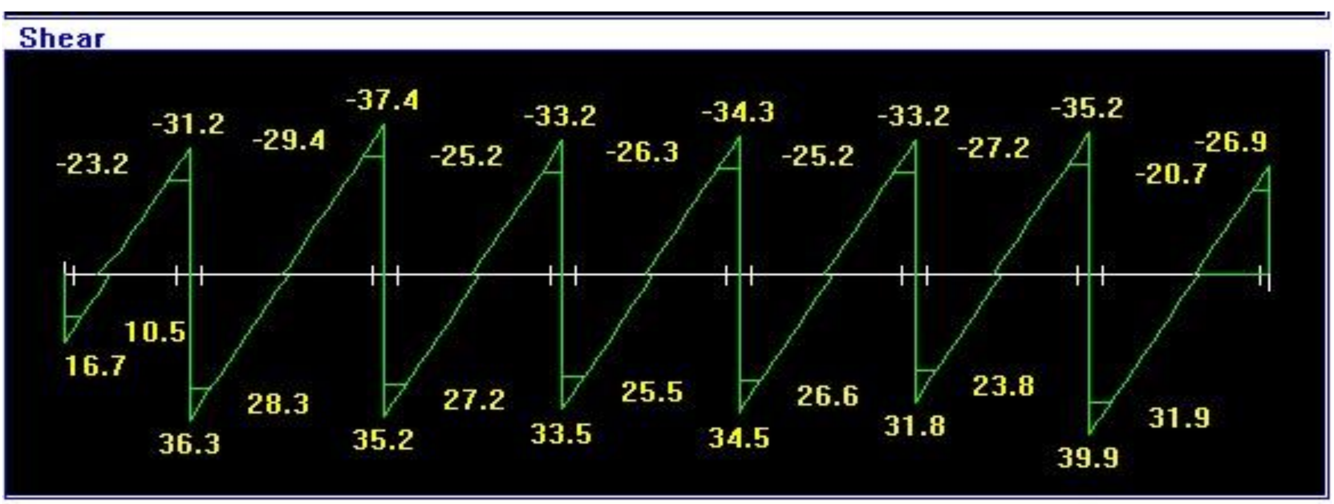


Figure (4 .10) Shear Envelop for Beam

Material :

concrete B300 Fc' = 24 N/mm^2

Reinforcement Steel fy = 420 N/mm^2

Section :- B = 50cm

h=50 cm d=500-40-10-

20/2= 440 mm

4.8 LOAD CALCULATIONS:-

The distributed Dead and Live loads acting upon (B 27) can be defined from the support reactions of the R14.

Dead Load and Live Load :-

From Rib 14

The maximum support reaction from Dead Loads for R14 upon B27 is 15.53 KN, The distributed Dead Load from the R14 on B27.

D_L = (15.53/ 0.5) =31.06 KN / m

The maximum support reaction (factored) from live loads for R14 upon B27 is 5.18 KN

L_L = (5.18/0.5) = 10.36 KN / m.

4.9 MOMENT DESIGN FOR (B31):-

Flexural Design of Negative Moment for (B31) :- (Mu= -173.8 KN.m)

d =500– 40 –10 – 20\2 = 440 mm

Take $\emptyset = 0.9$

M_u = 173.8 KN.m

Check whether the section will be act as singly or doubly reinforced section:

Maximum nominal moment strength from strain condition $\varepsilon_s = 0.004$

$$c = \frac{3}{7}d = \frac{3}{7} * 440 = 188.57\ mm$$

a= $\mathcal{B} * c = 0.85 * 188.57 = 160.28\ mm$

Mn_{max}= $0.85 * f_c' * a * b\ (d - \frac{a}{2})$ = $0.85*24*160.28*1000*(440 - \frac{160.28}{2}) * 10^{-6}$

= 1176.6 KN.m

$\emptyset$ Mn_{max} = 0.82* 1176.6 = 964.8 KN.m > Mu = 173.8 KN.m Design

the section as singly reinforced concrete section.

$$Rn = \frac{M_u}{\emptyset b d^2} = \frac{173.8 \times 10^6}{0.9 \times 1000 \times 440^2} = 0.997 Mpa$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85 \times 24} = 20.588$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) DRDTY = \frac{1}{20.588}\left(1 - \sqrt{1 - \frac{2 \times 20.588 \times 0.997}{420}}\right) = 0.00243$$

$A_s = \rho.b.d = 0.00243 \times 1000 \times 440 = 1069.2\ mm^2$

Check for $A_{s,min}$:-

$$As^{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420} * 1000 * 440 = 1283.06\ mm^2$$

As$^{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420} * 1000 * 440$ = 1466.67 mm^2 **Control**

Use 5 $\emptyset 20$ with As$_{provided}$ = 15.708 cm^2 > As$_{req}$= 14.66 cm^2 ….Ok

Check for spacing

$$\text{Sb} = \frac{1000 - 40 * 2 - 10 * 2 - 5 * 20}{4} = 200 \text{ mm} > 25\text{mm}$$

Check for strain:-

$$a = \frac{A_{s.}f_y}{0.85b\ f_c'} = \frac{1570.8.\times 420}{0.85\times 1000\times 24} = 32.34\ mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{32.34}{0.85} = 38.047\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{440-38.047}{38.047}\right) = 0.0316 > 0.005 \qquad \mathbf{0k}$$

Flexural Design of Positive Moment for(B31):- (Mu=220.9KN.m)

$$R_n = \frac{M_u}{\emptyset b d^2} = \frac{220.9\times 10^6}{0.9\times 1000\times 440^2} = 1.267\ Mpa.$$

$$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times 24} = 20.588$$

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.588}\left(1 - \sqrt{1 - \frac{2\times 20.588\times 1.267}{420}}\right) = 0.003116$$

A_s = ρ.b.d =0.003116×1000×440 = 1371.04 mm^2.

Check for $A_{s,min}$:-

As$^{min} = \frac{\sqrt{fc'}}{4(fy)}(bw)(d) = \frac{\sqrt{24}}{4*420} * 1000 * 440$ = 1283.06 mm^2

$$As^{min} = \frac{1.4}{(fy)}(bw)(d) = \frac{1.4}{420} * 1000 * 440 = 1466.67 \text{ mm}^2$$ **Control**

Use 5 ø20 Bottom, $A_{s,provided}$= 15.708cm^2>$A_{s,required}$= 14.66 cm^2 … Ok Check

spacing :-

$$Sb = \frac{1000 - 40 * 2 - 10 * 2 - 5 * 20}{4} = 200 \text{ mm} > 25\text{mm}$$

Check for strain:-

$$a = \frac{A_{s.fy}}{0.85b\, f_c'} = \frac{1570.8.\times 420}{0.85\times 1000\times 24} = 32.34\ mm$$

$$c = \frac{a}{\beta_1} = \frac{32.34}{0.85} = 38.047\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{440 - 38.047}{38.047}\right) = 0.0316 > 0.005 \qquad \mathbf{0k}$$

4.10 SHEAR DESIGN FOR (B 31):-

1. **Case 1 :-**

   V_u = 220.5 KN

   $V_c = \frac{1}{6}\sqrt{fc'}b_w\, d == \frac{1}{6}\sqrt{24} * 500 * 440 = 179.62$ KN

   Φ V_c= 0.75*179.62 =134.715 KN

   0.5 Φ V_c = 67.357

   V_u =220.5 > 0.5 Φ V_c = 67.357…… Not satisfied

2. **Case 2 :-**

   0.5ΦVc = 67.357< Vu = 220.5> Φ Vc=134.715 ……. Not satisfied

3. **Case 3:-**

$V^{smin} = \frac{1}{16} * \sqrt{f_c'} * b_w d = \frac{1}{16} * \sqrt{24} * 500 * 440 * 10^{-3} = 67.36$

$V^{smin} = \frac{1}{3} * b_w d = \frac{1}{3} * 500 * 440 * 10^{-3} = 73.33$…… control

$\emptyset V_c \leq V_u \leq \emptyset(V_c + V_{smin})$

134.715≤ 220.5> 189.7125……. Not satisfied

Cases 1&2&3 is not suitable

4. **Case 4 :-**

$V_{s'} = \frac{1}{3}\sqrt{fc'} b_w d = \frac{1}{3}\sqrt{24} * 500 * 440 = 359.258$

$\emptyset(V_c + V_{smin}) < V_u \leq \emptyset(V_c + V_{s'})$

189.7125<220.5 ≤ 404.158…… ok

shear reinforcement are required

Use 2 leg Φ 10

As =2*78.53=157.06 mm^2

$V_s = V_n - V_c = \frac{220.5}{0.75} - 179.62 = 114.38KN$

$$S = \frac{A_v f_{yt}\, d}{v_s} = \frac{157 * 420 * 440}{114.38 * 1000} = 253.659\ mm$$

$$s_{max} \leq \frac{d}{2} = \frac{440}{2} = 220\ mm \qquad \boldsymbol{control}$$

$$or \qquad s_{max} \leq 600\ mm$$

Use 2 leg Φ 10 @ 250mm

4.11 DESIGN OF ONE WAY SOLID SLAB (S2)

Material :-

⇒ concrete B300 Fc' = 24 N/mm^2

,

⇒ Reinforcement Steel fy = 420 N/mm^2

Slabs Thickness calculation:-

Min h (deflection requirement) ≥ :

- For both ends continuous one-way solid:

$$\frac{L}{28} = \frac{11}{28} = 0.39m$$

For One way solid slab ,will use thickness of slab **40 cm** .

Statically System and Dimensions:-

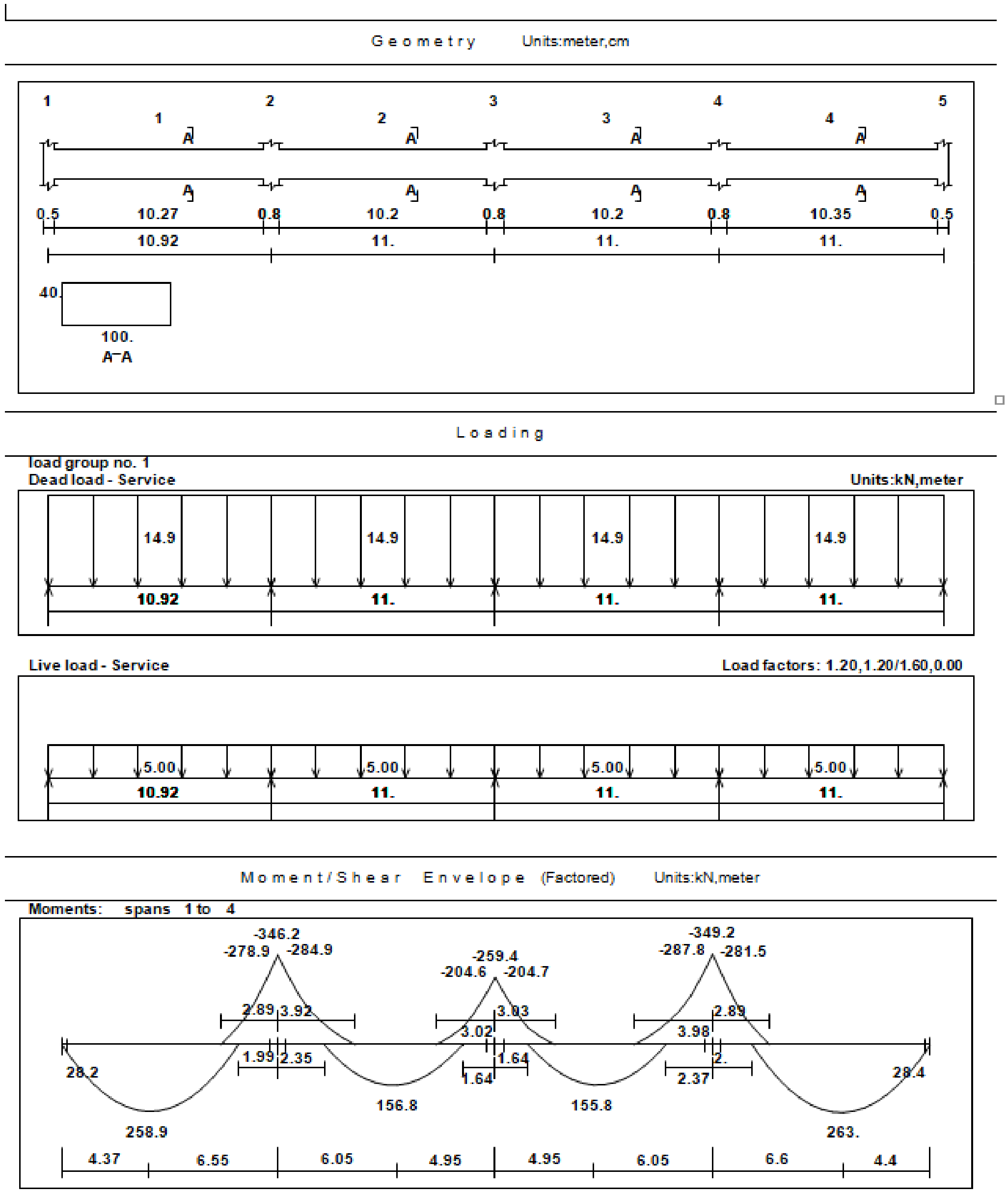


Figure (4. 11): Statically System and Loads Distribution and moment envelop of Solid Slab(S2).

Load Calculations:-

Dead Load:-

Table (4 .3): Dead Load Calculation of Solid slab (S2) .

No.	Parts of Beam	Calculation
1	Tiles	0.03*23*1 = 0.69 KN/m
2	Mortar	0.02*22*1 = 0.44 KN/m
3	Coarse Sand	0.07*17*1 = 1.19KN/m
5	RC. Slab	1*0.20*25 = 5 KN/m
7	plaster	0.03*22*1= 0.66 KN/m
8	partions	2.5*1= 2.5 KN/m

Sum = 10.48 KN/m

Live Load:-

LL=5KN/m .

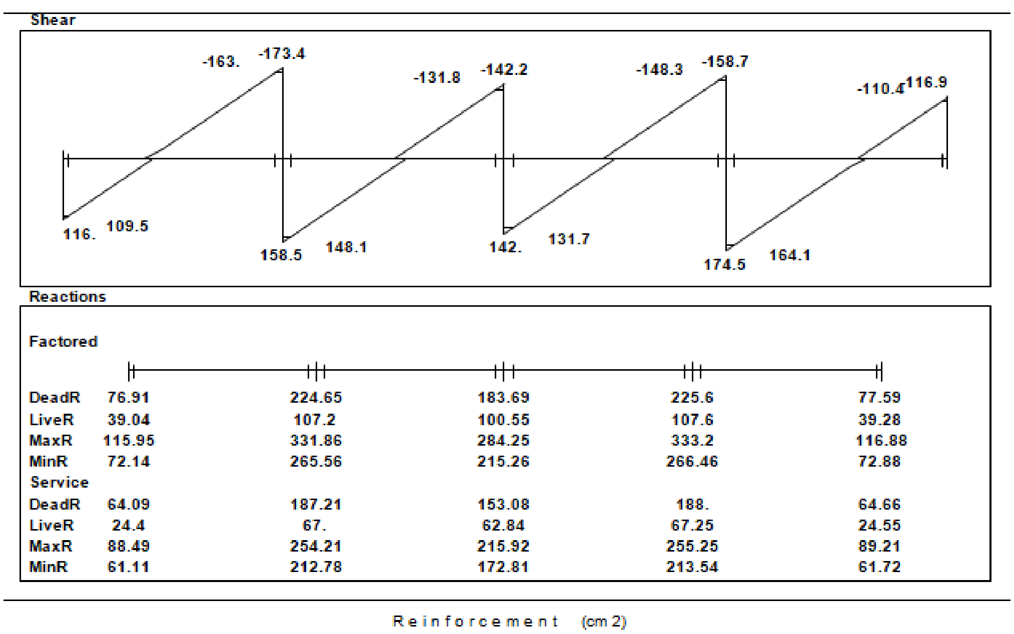


Figure (4. 12): Shear Envelope Diagram of Solid Slab(S2).

Design of slab:-

Assume bar diameter Ø16 for main reinforcement.

$$d = 400 - 20 - \frac{14}{2} = 373mm$$

For shear:

check whether thickness is adequate for shear:

$V_{u,\max}$ = 164.1 KN/1m strip

$$\emptyset Vc = \frac{1}{6} * 0.75 * \sqrt{fc'} * bw * d$$

$$= \frac{1}{6} * 0.75 * \sqrt{24} * 1000 * 373/1000 = 228.4 \text{ KN \\ 1m strip}$$

$$\emptyset Vc = 228.4 > V_{u,max} = 164.1$$

The thickness of the slab is adequate enough

For positive Moment:

Mu = 263 KN.m /m

m = $\frac{fy}{0.85 * fc'}$ = $\frac{420}{0.85 * 24}$ = 20.59

Rn = $\frac{Mu / \phi}{b * d^2}$

Rn = $\frac{263 * 10^{-3} / 0.9}{1 * (0.373)^2}$ = 2.1 N/mm² (Mpa)

ρ = $\frac{1}{m}$ (1 - $\sqrt{1 - \frac{2m * Rn}{fy}}$)

ρ = $\frac{1}{20.59}$ (1 - $\sqrt{1 - \frac{2(20.59)(2.1)}{420}}$) = 0.00258= 0.0018 ok $\rho_{\min}$ >

As = ρ * b * d = 0.00528* 1000 * 373= 1969.44 mm²

Check Minimum Reinforcement A^{s} min...(ACI- 318M-08 – (10.5.1))

As min = $\rho_{\min} * b * h = 0.0018 * 1000 * 400 = 720 mm^2$ (control)

As > As min

Asmin =720 mm2 <As req =1969.44mm2 .OK .

$\Rightarrow$ Use Φ1 4/ 15cm , As prov = 2308.5mm2/m

step (s) is the smallest of :-

$\le 380\ (\frac{280}{fs}) - 2.5 * C_c$

$\le 380 * (\frac{280}{\frac{2}{3}f_y}) - 2.5 * 20 = 380 * (\frac{280}{\frac{2}{3} * 420}) - 2.5 * 20 = 330mm$

$\le 300\ (\frac{280}{fs}) = 300 * (\frac{280}{\frac{2}{3}f_y}) = 300 * (\frac{280}{\frac{2}{3} * 420}) = 300$ mm (control)

≤ 3 * h = 3* 400 = 1200 mm

≤ 450 mm.

$\text{S} = 150\ \text{mm} \le \text{Smax} = 300\ mm$

∴Use Φ1 4@ 1 5cm in main directions.

For Negative Moment:

- $d = 400 - 20 - \frac{16}{2} = 372mm$

Mu = -284.9 KN.m /m

m = $\frac{fy}{0.85 * fc'} = \frac{420}{0.85 * 24}$ = 20.59

Rn = $\frac{Mu / \phi}{b * d^2}$

Rn = $\frac{284.9 * 10^{-3} / 0.9}{1 * (0.372)^2}$ = 2.28 N/mm² (Mpa)

ρ = $\frac{1}{m}$ (1 - $\sqrt{1 - \frac{2m * Rn}{fy}}$)

ρ = $\frac{1}{20.59}$ (1 - $\sqrt{1 - \frac{2(20.59)(2.28)}{420}}$) = 0.0057= 0.0018 ok $\rho_{\min}$

As = ρ * b * d = 0.0057* 1000 * 372= 2120.4 mm²

Check Minimum Reinforcement A^s min...(ACI- 318M-08 – (10.5.1))

As min = $\rho_{\min} * b * h = 0.0018 * 1000 * 400 = 720 mm^2$ (control)

As > As min

Asmin =720 mm2 <As req =2120.4mm2 .OK .

$\Rightarrow$ Use Φ16 / 15cm , As prov = 3016.5 mm2/m step (s) is the smallest of :-

$\leq 380\ (\frac{280}{fs}) - 2.5 * C_c$

$\leq 380 * (\frac{280}{\frac{2}{3} f_y}) - 2.5 * 20 = 380 * (\frac{280}{\frac{2}{3} * 420}) - 2.5 * 20 = 330mm$

$\leq 300\ (\frac{280}{fs}) = 300 * (\frac{280}{\frac{2}{3} f_y}) = 300 * (\frac{280}{\frac{2}{3} * 420}) = 300$ mm (control)

$\leq 3 * h = 3 * 400 = 1200$ mm

≤ 450 mm.

$S = 150 \text{ mm} \leq Smax = 300\ mm$

∴Use Φ16 @ 1 5cm

Temperature and Shrinkage :

$\rightarrow \rho = 0.0018$

A s min = $\rho_{min} * b * h = 0.0018 * 1000 * 400 = 720 mm^2$

Use Φ1 4@ 2 00mm

4-12: DESIGN OF STAIRS

Material :

⇒ concrete B300 $Fc' = 24 N/mm^2$

⇒ Reinforcement Steel $Fy = 420\ N/mm^2$

- **Design of Flight :**

Determination of Thickness:

$h_{min} = L/20$

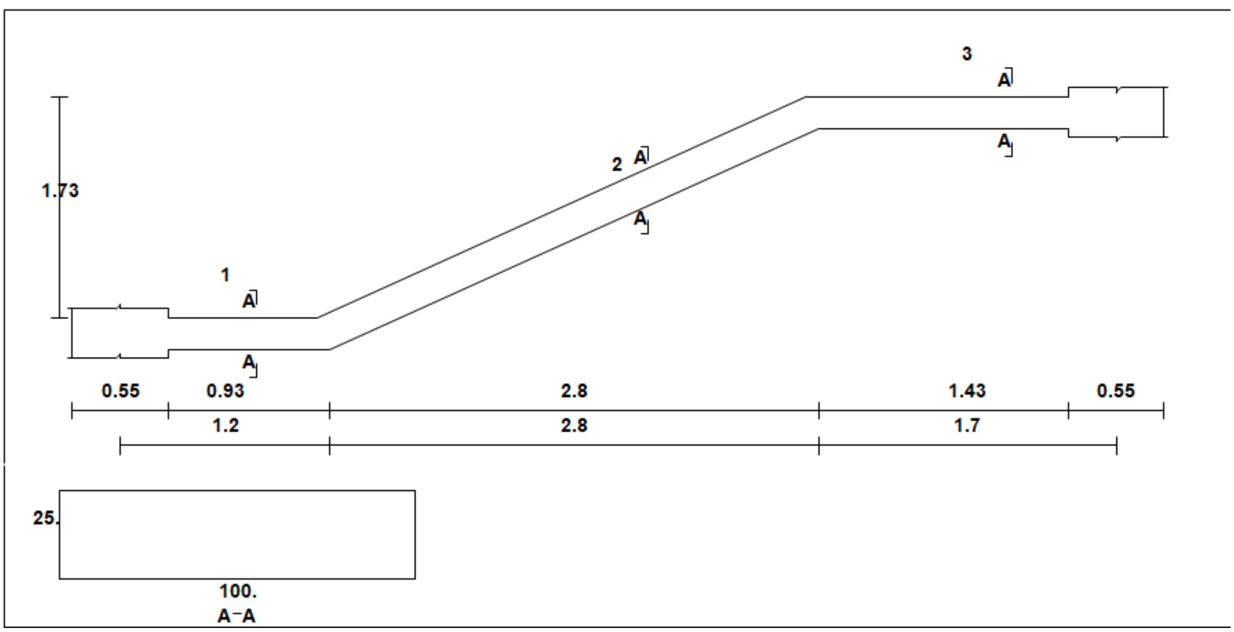


Figure (4. 13) stairs spans

$h_{min} = 5400/20 = 270$ mm

Take h = 25 cm

The Stair Slope by $\theta = \tan^{-1}(17.3/\ 30) = 29.97$

Load Calculation:

Dead Load For Flight For 1m Strip:

Table (4 .4) Calculation of the total dead load for flight

material	Quality density	W kn/m
tiles	27	$27(\frac{0.173+0.35}{0.3})*0.03*1=1.412$
mortat	22	$22(\frac{0.173+0.30}{0.3})*0.02*1=0.694$
Stair steps	25	$25/0.3(\frac{0.173*0.30}{2})*1=2.16$
Rc solid slab	25	$\frac{25*0.25*1}{cos29.97}=7.21$
Plaster	22	$\frac{022*0.03*1}{cos29.97}=0.76$
Total dead load kn/m		=12.236 kn/m

Live load =5 kn /m

W_U = 1.2 ×12.236+ 1.6×5 = 22.6832KN/m

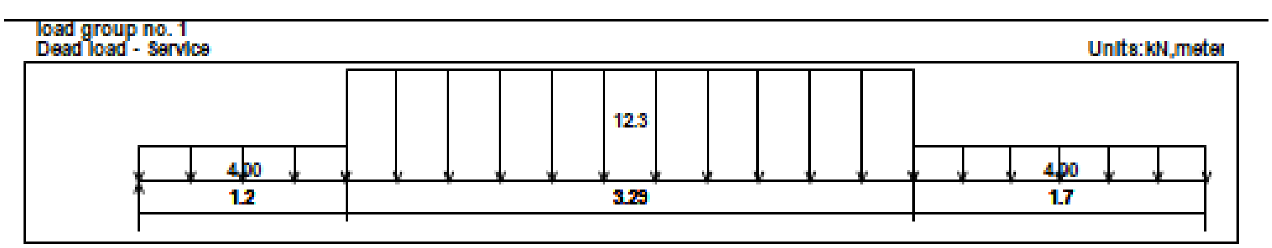
Table (4 .5) Calculation of the total dead load for landing

material	Quality density	W kn/m
tiles	23	23*0.03*1=0.69
mortat	22	22*0.02*1=0.44
rc	25	25*0.25*1=6.25
plaster	22	22*0.03*1=0.66
Total dead load kn/m		=8.04 kn/m

Live load =5 kn /m

Factored Load For Flight :
W_U = 1.2 ×8.04+ 1.6×5 = 17.648KN/m because the load on landing is carried into two dirictions,only half of the load will be considered in each direction 17.648/2=8.824

Dead Load For LANDING For 1m Strip:



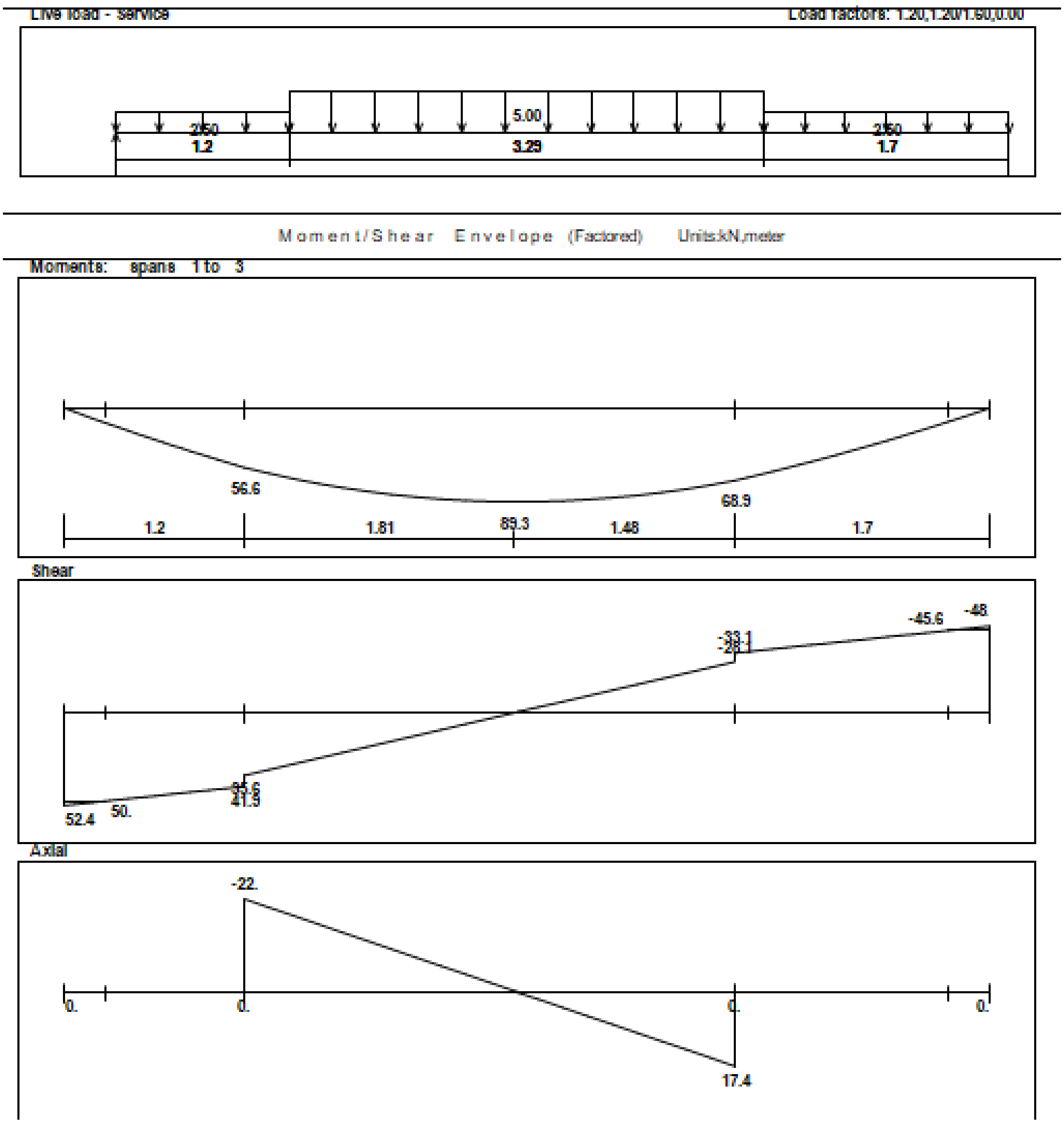


Figure (4. 14)stair Geometry ,moment and shear envelop

Design of Shear for Flight :

(Vu=45.6 Kn)

Assume bar diameter ø 14 for main reinforcement

d = h- cover $-\frac{d_b}{2} = 250 - 20 - \frac{14}{2} = 223\ mm$

$V_c = \frac{1}{6}\sqrt{fc'} b_w\ d == \ \frac{1}{6}\sqrt{24} * 1000 * 223 = 182$Kn

$\Phi\ V_c =$ 0.75* 182 = 136.56 KN > Vu = 45.6Kn

0.5Φ V68.27>Vu = 45.6Kn**…… No shear reinforcement are required**

Design of Bending Moment for Flight :

(Mu=89.3 Kn.m)

$R_n = \frac{M_u}{\emptyset bd^2} = \frac{89.3\times10^6}{0.9\times1000\times223^2} = 1.99Mpa$

$m = \frac{f_y}{0.85f_c'} = \frac{420}{0.85\times24} = 20.59$

$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2.m.R_n}{420}}\right) = \frac{1}{20.59}\left(1 - \sqrt{1 - \frac{2\times20.59\times1.99}{420}}\right) = 0.00499$

$A_{s,req}$ = ρ.b.d = 0.00499 ×1000×273= 1362.27 mm^2/m

$A_{s,min}$= 0.0018*1000*250 = 450mm^2/m

As_{req} = 1362.27 mm^2>$A_{s,min}$= 450mm^2/m

1362.27/254=5.36

1/5.36 =186mm

Take ø18@15cm

Check for Spacing :

S = 3h = 3*250 =750 mm

S = 380*$(\frac{280}{\frac{2}{3}*420})$ – 2.5*20 = 330

S = 450 mm

S = 330mm **……… is control**

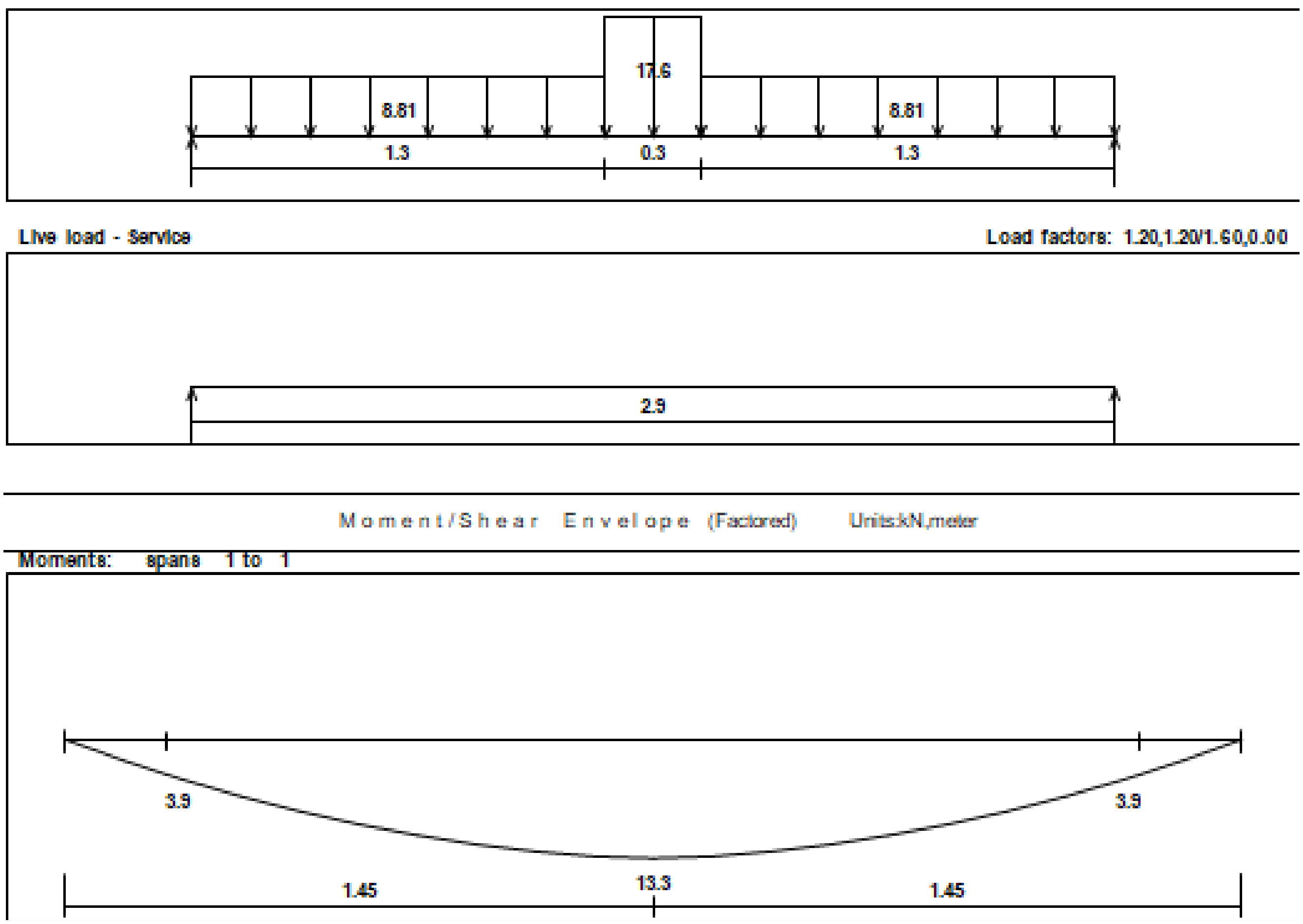
$$a = \frac{A_{s}.f_y}{0.85b\, f_c'} = \frac{1362.27 \times 420}{0.85 \times 1000 \times 24} = 28.04\ mm$$

$$c = \frac{a}{\mathcal{B}_1} = \frac{28.04}{0.85} = 32.99\ mm$$

$$\varepsilon_s = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{273-32.99}{32.99}\right) = 0.0218 > 0.005 \quad \ldots\ldots \mathbf{0k}$$

Lateral or Secondary Reinforcement For Flight :

$A_{s,req} = A_{s,min} = 0.0018*1000*300 = 540mm^2$



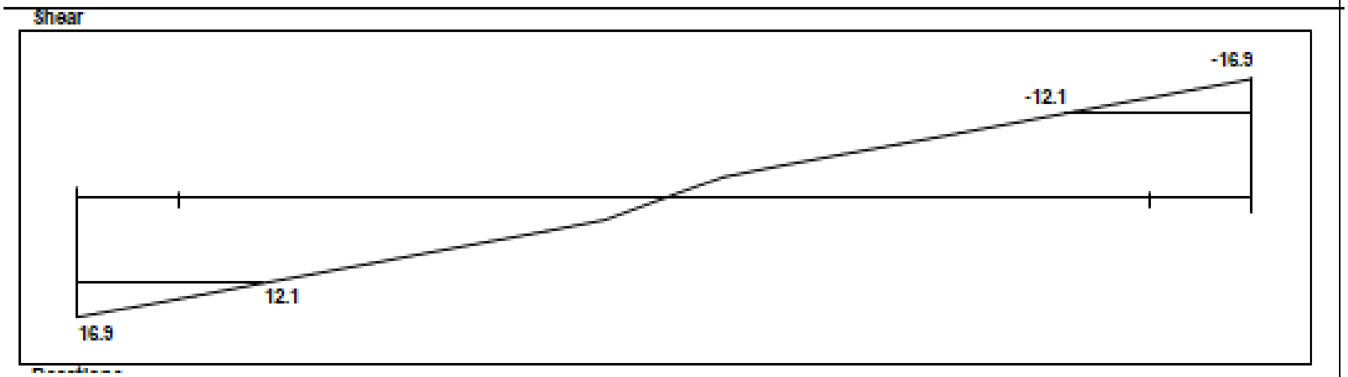


Figure (4 .15) landing Geometry ,moment and shear envelop

Design of Bending Moment for landing:

(Mu=1.8 Kn.m)

$R_n = \frac{M_u}{\emptyset b d^2} = \frac{1.45\times10^6}{0.9\times1000\times223^2} = 0.032Mpa$

$m = \frac{f_y}{0.85 f_c'} = \frac{420}{0.85\times24} = 20.59$

$\rho = \frac{1}{m}\left(1-\sqrt{1-\frac{2.m.R_n}{420}}\right) = \frac{1}{20.59}\left(1-\sqrt{1-\frac{2\times20.59\times0.032}{420}}\right) = 7.625*10^{-5}$

$A_{s,req}$ = ρ.b.d = $7.625*10^{-5}$×1000×223= 17mm^2/m

$A_{s,min}$= 0.0018*1000*250 = 450mm^2/m

450/113.1=3.97

1/3.97=0.25m

Take ø12@25cm

4.13 :DESIGN OF COLUMN (C54)

Material :-

⇒ concrete B350 Fc' = 2 8N/mm^2

⇒ Reinforcement Steel Fy = 420 N/mm^2

Load Calculation:-

Service Load:-

Dead Load =142.07 KN

Live Load =21.59 KN

Factored Load:-

P_U = 1.2 ×142.07+ 1.6×21.59 =205.028 KN

Dimensions of Column:-

$P_U = 205.028$

$P_n = 205.028$/0.65 = 315.427

$Assume\rho g = 0.01$

$Pn = 0.8 \times Ag\{0.85\, fc + \rho g * (Fy - 0.85\, fc)\}$

$315.427 = 0.8 \times Ag\{0.85 * 28 + 0.01 * (420 - 0.85 * 28)\}$

Ag= 142022.819 mm2

Select 45*60cm with Ag= 2700

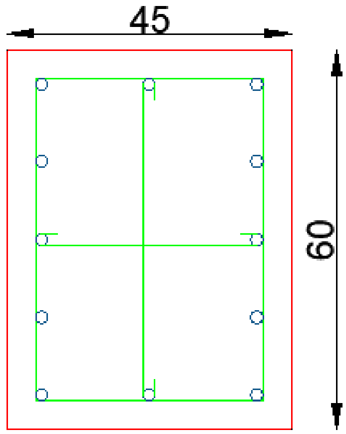


Figure (4. 16): Column section

Check Slenderness Parameter:-

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \leq 40$$

Lu: Actual unsupported (Unbraced) length.

K: effective length factor. According to ACI 318-2002 (10.10.6.3) The effective length factor k, shall be permitted to be taken as 1.0.

R: radius of gyration = $\sqrt{\frac{I}{A}}$ ≈0.3 h ……………….For rectangular section

Lu = 3.55 - 0.7= 2.85 m
M1/M2 =1
K=1 for braced frame.

- **about Y-axis (b= 0.60 m)**

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad \leq 40$$

- $\frac{1 \times 2.85}{0.3 \times 0.60} = 15.83 < 22$

Column Is Short About Y-axis

- **about X-axis (h= 0.45m)**

$$\frac{klu}{r} < 34 - 12\frac{M1}{M2} \quad ....ACI - (10.12.2)$$

$$\frac{1 \times 2.85}{0.3 \times 0.45} = 21.11 < 22$$

Column Is Short About X-axis

Minimum Eccentricity:-

$$ey = \frac{Mux}{Pu} = 0$$
$$\min ey = 15 + 0.03 \times h = 15 + 0.03 \times 600 = 33mm = 0.033m$$
$$ey = 0.0285m$$

Magnification Factor:-

$$\delta_{ns} = \frac{Cm}{1 - \frac{Pu}{0.75P_c}} \geq 1.0 and \leq 1.4$$

$$Cm = 0.6 + 0.4\left(\frac{M1}{M2}\right) \geq 0.4$$
$$Cm = 0.6 + 0.4 * 1 = 1 \geq 0.4$$

$$P_{cr} = \frac{\pi^2 EI}{(KLu)^2}$$

$$EI = 0.4\frac{E_c I_g}{1+\beta_d}$$

$$E_c = 4700\sqrt{fc'} = 4700\times\sqrt{28} = 24870.6Mpa$$

$$\beta_d = \frac{1.2DL}{Pu} = \frac{1.2*(142.07)}{205.028} = 0.83 < 1$$

$$I_g = \frac{b\times h^3}{12} = \frac{0.45\times 0.6^3}{12} = 0.0081m^4$$

$$EI = \frac{0.4\times 24870\times 0.0081}{1+0.83} = 44.032MN.m^2$$

$$P_{cr} = \frac{\pi^2 * 44.032}{(1*2.85)^2} = 53.50MN$$

$$\delta_{ns} = \frac{1}{1-\frac{205.028}{0.75*53503.037}} = 1.005 \geq 1.0 and \leq 1.4$$

$$ey = e_{\min}\times\delta_{ns} = 0.024\times 1.005 = 0.0241m$$

$$\frac{ey}{h} = \frac{0.0241}{0.6} = 0.04$$

$$\frac{\gamma}{h} = \frac{300-2*40-2*10-18}{350} = 0.52$$

From the interaction diagram chart

from chart A9 - a for $\frac{\gamma}{h} = 0.6 \rightarrow \rho g = 0.01$

from chart A9 - b for $\frac{\gamma}{h} = 0.75 \rightarrow \rho g = 0.01$

then for $\frac{\gamma}{h} = 0.52 \rightarrow \rho g = 0.01$

Select reinforcement

Ast = $\rho g \times Ag = 0.01\times 450*600 = 2700mm^2$

Select $12\,\phi 18$ *with* $As = 3054mm^2 >$ Ast $= 2700mm^2$.

Design of the Stirrups:-

The spacing of ties shall not exceed the smallest of :-

$$spacing \leq 16 \times d_b = 16 \times 2.0 = 25.6\, cm$$

$$spacing \leq 48 \times d_s = 48 \times 1.0 = 48\, cm$$

$$spacing \leq 40\, cm$$

$Use\,\phi 10 @ 20\, cm$

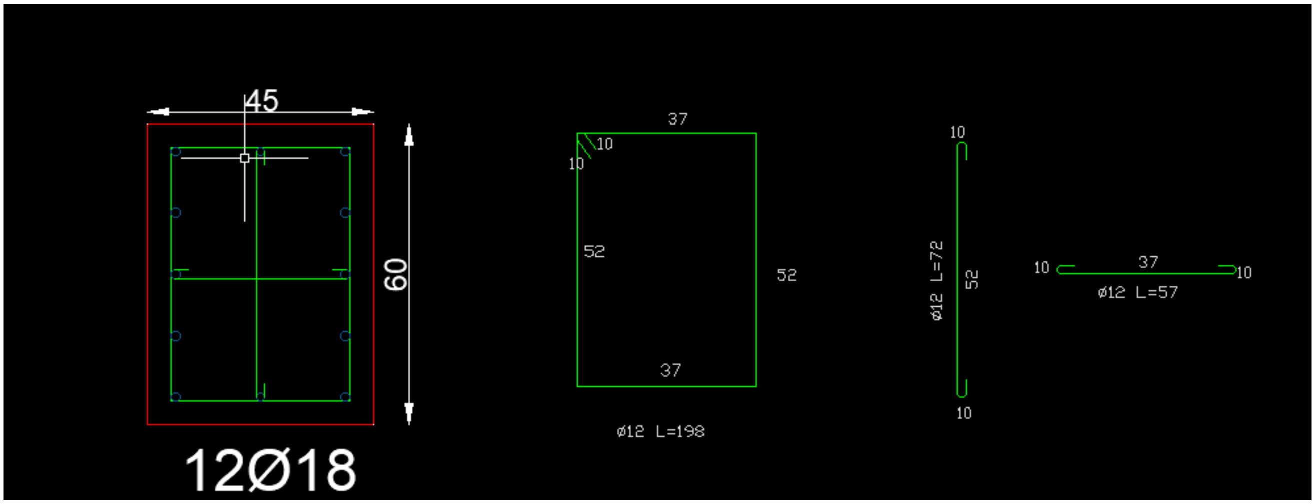


Figure (4. 17): Column Reinforcement Details.

4.14: DESIGN OF FOUNDATION FOR (C54):

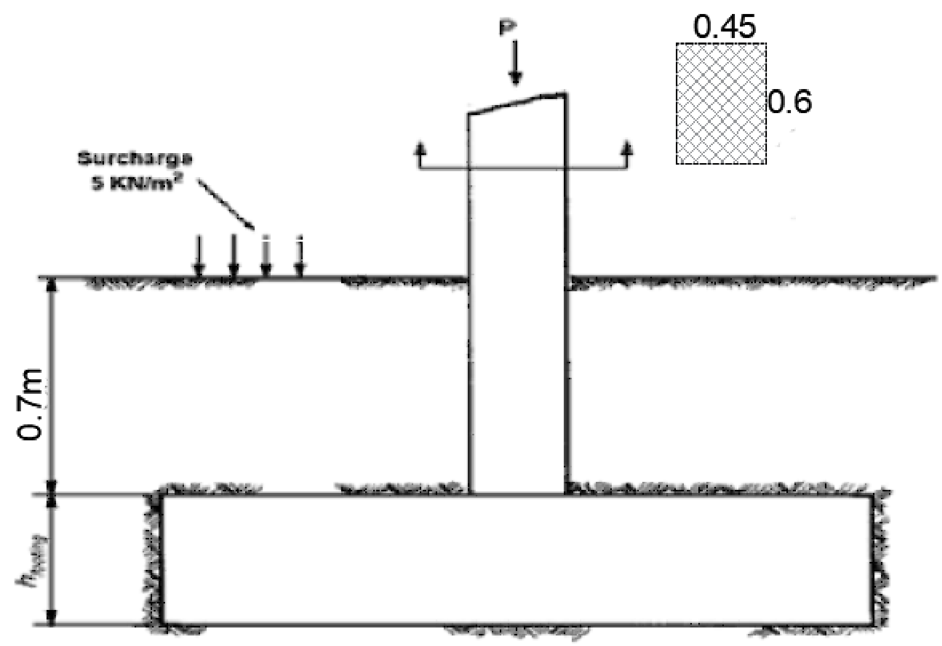
Fc̀=24Mpa Fy=420Mpa

Dl=1443kn LL=215.9kn

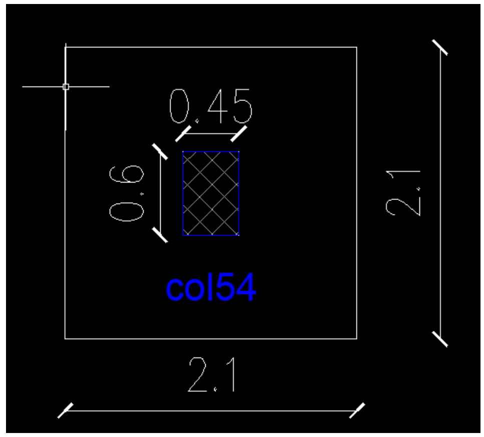
Pu=1.2*Dl+1.6*LL=1.2*1443+1.6*215.9=2068.5

$Pu_{service}$=Dl+LL=1443+215. 9=1653.59

Assume surcharge =5kn/m^2
Qa=400kn/m^2
$\gamma soil = 17kn/m^3$
Assume h $_{footing}$ =40 cm
w $_{footing}$ =0.4*25=10kn/ m^2
w $_{soil}$ =0.7*17=11.9kn/ m^2
total surcharge load on foundation =10+11.9+5=26.9kn/m^2



Fc̀=28Mpa Fy=420Mpa
$Q_{a,net}$=400-26.9=373.1kn/m^2
A=$P_n/q_{a,net}$
A=11653.59/373.1=4.4 L=$\sqrt{A}$
L=2.09m take L=2.1m



Depth of footing and shear design

Pu=1.2*Dl+1.6*LL=1.2*1443+1.6*215.9=2068.5
Q_u=2068.5/2.1*2.1=469.04kn/m^2

One way shear

$V_u=q_u b(\frac{l}{2}-\frac{a}{2}-d) = 469.04 * 2.1(\frac{2.1}{2}-\frac{0.45}{2}-d)$
Let $v_u=\emptyset v_c$

$$\frac{469.04 * 2.1}{0.75}\left(\frac{2.1}{2}-\frac{0.45}{2}-d\right)=\frac{1}{6}\sqrt{24} * 2100 * d$$

D=0.55m
Assume cover =75mm and$\emptyset = 20mm$
h=0.55+0.075+0.02=0.645mm
take h=700
d=700-75-20=605mm

tow way shear :

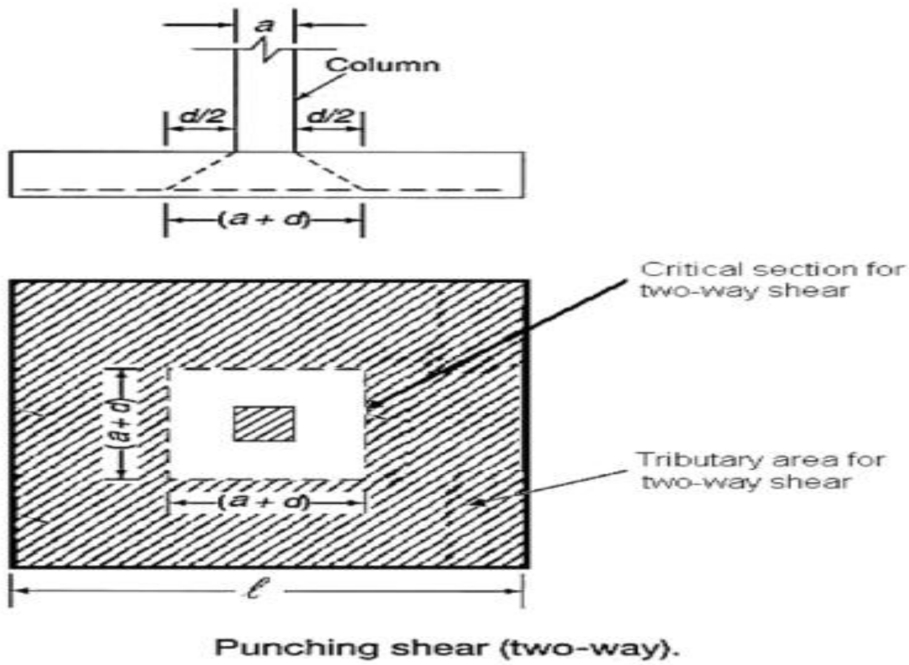


Figure (4 .18) punching shear

Let v_u=Øv_c

v_u=469.04(2.1*2.1-(0.8+d)(0.55+d)

v_u =469.04(2.1*2.1-(0.8+0.605)(0.55+0.605)=1307.32kn

$\beta = \frac{450}{600} = 0.75$

B_0=2(0.8+0.605)+2(0.55+0.605)=5.12m

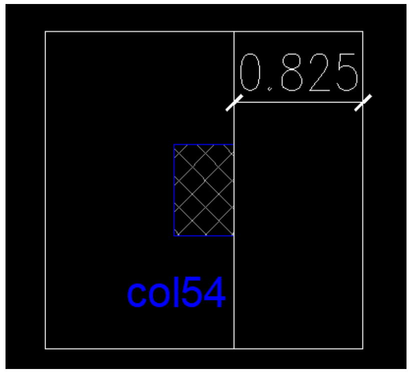
Vc=1/3√(fc`)*bo*d

Vc=1/3*$\sqrt{24}$*5120*605*10^{-3}=5058.35kn ……….control

øVC=0.75*5058.35=3793.76kn

3793.76kn>1307.32 ok

design for flexure in short direction:



d=700-75-20/2=615
(2.1-0.45)/2=0.825
Mu=469.04*2.1*0.825*0.825/2=335.2 kn.m
Rn =Mu/øbd2 =335.2*10^6/0.9*2.1*615^2=0.468Mpa
M=Fy/0.85* fc`=420/0.85*24=20.58

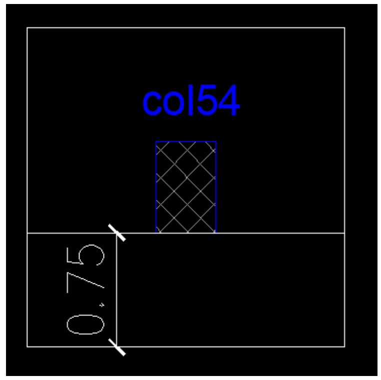
$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right)$$

$$\rho = \frac{1}{20.58}\left(1 - \sqrt{1 - \frac{2*0.468*20.58}{420}}\right) = 0.001127$$

As= ρ*b*d =0.001127*2100*615=1455.52mm^2
As (min)= 0.0018*b*h =0.0018*2100*700=2642 mm^2……….control
As= 1455.52< As (min)=2642

Take 11ø18 As=11*254.5=2799.5mm^2>2642mm^2…ok
S=2100-75*2-11*18/10=175.2mm
S max=3h =3*700=2100mm
Or 450mm…… control
S= 175.2 < S max= 450 ….. Ok

design for flexure in long direction:



d=700-75-20/2=615

(2.1-0.6)/2=0.75
Mu=335.2*2.1 *0.75*0.75/2=197.977kn.m
Rn =Mu/øbd2 =197.977*10^6/0.9*2100*615^2=0.277 Mpa
M=Fy/0.85* fc` =420/0.85*24=20.58

$$\rho = \frac{1}{m}\left(1 - \sqrt{1 - \frac{2*R_n*m}{f_y}}\right)$$

$$\rho = \frac{1}{17.65}\left(1 - \sqrt{1 - \frac{2*0.277*20.58}{420}}\right) = 0.00066$$

As= ρ*b*d =0.00066*2100*615=857.6mm^2
As (min)= 0.0018*b*h =0.0018*2100*700=2642 mm^2……….control
As= 857.6< As (min)=2642
Take 11ø18 As=11*254.5=2799.5mm^2>2642mm^2…ok
S=2100-75*2-11*18/10=175.2mm
S max=3h =3*700=2100mm
Or 450mm…… control
S= 175.2 < S max= 450 ….. Ok

4.15: DESIGN OF BASEMENT WALL :

- We input this information on Etabs and the program outputs the value of the moment Mu = 84.2KN.m

  Fc̀=24Mpa

  Fy=420Mpa

  γ =17kn/m^3

  C = 0

  θ "internal friction"=30°

  Mu = 84.2KN.m

- $d = 300 - 50 - \frac{20}{2} = 240\ mm$

m = $\frac{fy}{0.85 * fc'}$ = $\frac{420}{0.85 * 24}$ = 20.59

Rn = $\frac{Mu / \phi}{b * d^2}$

Rn = $\frac{84.2 * 10^6 / 0.9}{1000 * (240)^2}$ = 1.62 N/mm^2 (Mpa)

ρ = $\frac{1}{m}$ (1 - $\sqrt{1 - \frac{2m * Rn}{fy}}$)

ρ = $\frac{1}{20.59}$ (1 - $\sqrt{1 - \frac{2(20.59)(1.62)}{420}}$) = 0.0040

As = ρ * b * d = 0.0040* 1000 * 240= 973 mm²

n= $\frac{973}{154}$=6.32

Use 7Φ14/m or Φ14@125mm

For Vertical take the minimum

As min = $\rho_{\min} * b * h$ $= 0.0012 * 1000 * 300 = 360 mm^2$

Or

As min $= 0.25 \times \frac{1}{420} \times \sqrt{24} \times 1000 \times 243 = 708.6$

Or

As min $= \frac{1.4}{420} \times 1000 \times 243 = 810$

Take 7Φ12/m or Φ12@125mm

5

CHAPTER FIVE: RESULTS AND RECOMMENDATIONS

5.1 Introduction

5.2 Results

5.3 Recommendations

5.1 INTRODUCTION

In this project, architectural plans were obtained that lacked many things. After studying all the requirements, the comprehensive architectural and construction plans for the proposed hotel in the city of Hebron were completed.

The construction plans have been prepared in a detailed, accurate and clear manner to facilitate the construction process. This report provides an explanation of all the steps of the architectural and structural design of the building.

5.2 RESULTS

1. Each student or structural designer must be able to design manually so that he can have experience and knowledge in the design programs and to emphasize the solution of the calculated programs and to understand how they work.

2. the factors that must be taken into consideration are the natural factors surrounding the building, the nature of the site, and the effect of natural forces on the site .

3. One of the most important structural design steps is how to link the various structural elements through the holistic view of the building and then segmenting these elements to design them individually and knowing how to design, taking into consideration the conditions surrounding the building .

5.3 RECOMMENDATIONS

This project increasing our understanding the construction projects with all their details, analyzes and designs. We would like here - through this experience - to present a set of recommendations, which we hope will be of benefit and advice to those planning to choose projects of a construction :

1. There must be coordination between the architectural and structural designer during the design process in order to result in an integrated building, both structurally and architecturally.

2. information about the site, its soil and the durability of the site's soil must be available through a geotechnical report specific to that area.

3. It is recommended to have a supervising engineer to supervise the implementation and to abide by the plans and conditions to ensure the best implementation of the project.

4.The electrical and mechanical design of the project must be completed before the start of implementation to edit any possible structural edit required .

REFERENCE

- ACI 318-08 (American Code)
- Jordan Code
- Reinforced concrete I, II III,(DR. Nasser Abboshi)